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THE MEDICAL CONGRESS AT ROME.

AT the recent Medical Congress (eleventh), held March 29, 1894, at Rome, 7,612 members registered. The first congress was held at Florence, in 1869, with an attendance of only 350. In the present congress the lead was naturally taken by Italy, which furnished 1,900 members, Germany came next with 900, followed by Austria-Hungary and the United Kingdom with 700 each. France came next with 600, followed by Spain with 250, Russia with 200, and the United States with 170, which is a very good showing, considering the time and expense required to reach Italy from America. The time was filled up by general papers, by special papers read before the various sections, and by entertainments furnished by the hospitable Romans. We illustrate the fete held in the Baths of Caracalla, and also give a portrait of M. Baccelli, president of the Medical Congress, for both of which we are indebted to *L'Illustration*, also a sketch of the opening scene from the *Graphic*, London.

The garden party at the Quirinal Palace and the lunch in the Baths of Caracalla will doubtless leave an indelible impression on the minds of the members of the congress. The gardens of the Quirinal possess great beauty and dignity, and were admirably adapted to hold the three thousand invited guests. A red and yellow pavilion, partly rustic, partly oriental, formed the reception room. Two orchestras, two buffets, and a dancing pavilion were installed in the garden. The king and the queen descended the steps of the palace, followed by their gentlemen and ladies of honor. Many of the *savants* and their wives or daughters were presented to the queen. The garden party was an aristocratic fete; not so the lunch. Twelve thousand invitations were issued. In this Pantagruelian feast the total amount of provisions consumed was enormous. Two deer, forty lambs, forty kids, four hundred pieces of beef, one hundred hams, two thousand five hundred chickens, twenty thousand cakes, forty thousand Vienna rolls, twelve tuns of wine, nine thousand bottles of wine, besides ices, coffee, etc., were consumed by the hungry crowd—truly a Roman orgy. Precisely at noon the barriers were thrown down and the assault upon the tables began. Naturally, half the guests went hungry, for in thirty minutes nothing was left but *debris*. After the lunch the guests examined the enormous ruins, the gigantic proportions of which never cease to cause wonder.

M. Baccelli, President of the Medical Congress, Rome.

Professor Baccelli, upon whose eloquence endless calls were made throughout the week, made an apt little speech. "From these glorious ruins," he said, "the spirits of ancient Rome rise for you to-day. She trusts that by your talents you will perpetuate her glory. In this immortal city, which once ruled the world with the sword, to which nations and their kings were dragged as prisoners, to-day and along this same *Via Sacra* welcomes all that is most advanced in human knowledge. It is a new *via sacra* of liberty and science."

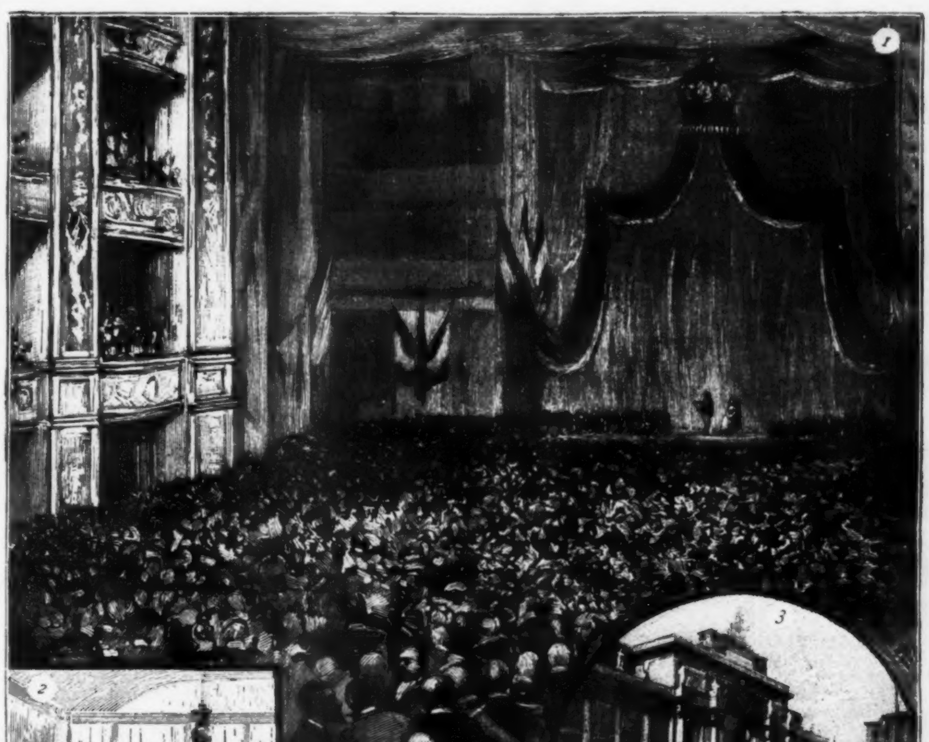
Hundreds of valuable papers were read in the different sections. From the *Medical Record* we take the following:

Dr. Luigi Cantu, of Pavia, in a paper upon the influence of temperature upon intestinal fermentation, said that he had several times observed a syndroma of phenomena consisting essentially in severe and painful cramps of the stomach, nausea, vomiting, wandering abdominal pains, borborygmi, slight fever, etc. At the same time the skin of the entire body was covered with the characteristic eruption of urticaria. The troubles disappeared completely in four or five days. The symptoms were referred by the author to auto-intoxication of intestinal origin, caused by an exaggerated peristalsis of the stomach, and secondarily of the intestine, excited by rapid oscillations of the atmospheric temperature acting upon the abdominal region. He had observed the same morbid complex in persons who had slept with abdomen uncovered in a room, the window of which was open during the night. Upon measuring in these individuals the intensity of the fermentative processes by the dosage of sulphonic ethers in the urine, he had found these processes always greatly increased. He had found, however, that the application of ice bags to the abdomen retarded digestive fermentation to a marked degree, and this would furnish an indication for their use in attacks similar to those above described.

Dr. Burney Yeo, of London, presented a communication upon the management of fevers and particularly of typhoid fever, of which the following were the conclusions: 1. Recently acquired knowledge as to the nature and causes of specific fevers demands a modification in the therapeutic conceptions and indications applied to their management. 2. To counteract or antagonize the pyrogenic and other poisons secreted by micro-organisms introduced into the body from without is an essential therapeutic indication in the treatment of fevers. 3. The investigation into the existence, scope, and activity of such counteracting therapeutic agents is of paramount importance to the rational treatment of fevers, and already the results of clinical observations give promise of fruitful conclusions to researches in this direction. 4. The search for direct antagonists to the poisons of specific fever is as important and probably of as great practical advantage as is that for methods of producing immunity. 5. The course and character of specific fevers can be, and have been, favorably modified and influenced by the administration of such antagonists. 6. Certain specified methods commonly adopted in the management of fevers, and especially of enteric fever, require modification and correction (*a*) in the direction of diet and regimen, and (*b*) in the direction of drug treatment.

Dr. Juhel-Renoy, of Paris, read a paper on the treatment of the typhoid state, of which the following were the main points: all infectious diseases may assume the typhoid aspect, and when this occurs refrigerant treatment is indicated. The method of this refrigerant medication must vary according to the result which it is desired to obtain. It is vastly superior to any other procedure in all forms of infectious fever; it reduces the total mortality of typhoid fever to seven per cent.; of typhoid erysipelas to nine per cent.; of malignant scarlatina to fourteen per cent.; of ataxo-adynamic measles to an almost inappreciable figure. The mortality of adynamic grippal pneumonia is reduced one-half by cold baths, and smallpox, when treated in this way from the start, is much milder in its course. The ways in which cold baths bring about the disappearance of the typhoid condition are numerous, but that which seems to be the most important as well as the most constant is the urinary crisis, an indication, when it occurs, of an early cure.

Dr. H. Chiari, of Prague, read a paper on typhoid bacilli in the gall bladder, in which he said that the systematic bacteriological examination of the contents of the gall bladder in cases of enteric fever almost always revealed



1 The inauguration by the King of Italy in the Costanzi theater.

2. The opening, by Signor Crispi, of the Hygienic Exhibition.

3. The exterior of the Hygienic Exhibition building.

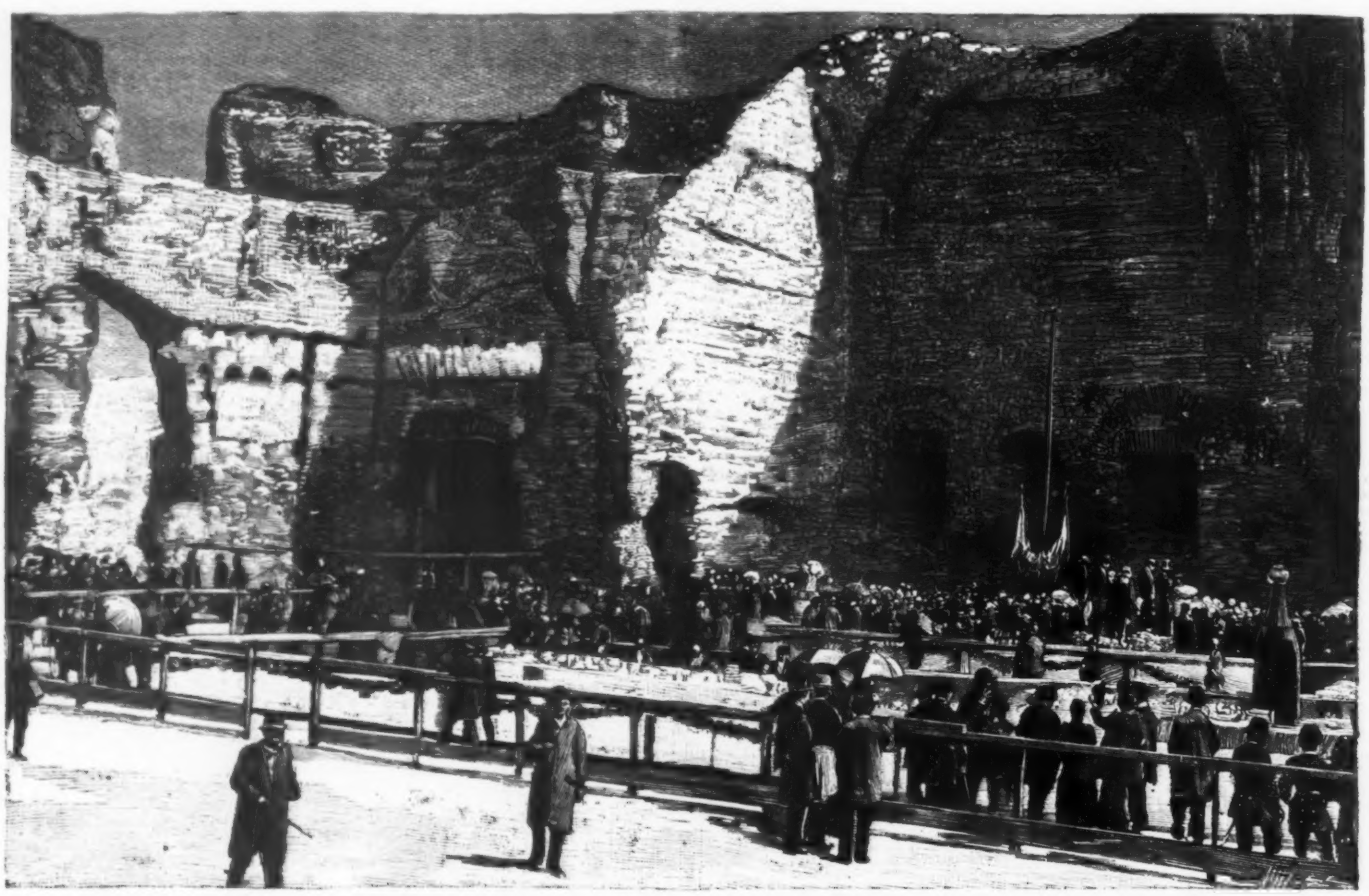
THE INTERNATIONAL MEDICAL CONGRESS AT ROME.

the presence of typhoid bacilli. The bacilli may increase in numbers here and induce an inflammation of the gall bladder, and possibly there is in this fact an explanation for certain cases of relapse in typhoid fever. The bacilli gain entrance either through the blood or by direct ascent through the common bile duct from the intestine.

ARCHÆOLOGY AND MEDICINE IN ROME.

By Commendatore RODOLFO LANCIANI, Professor of Roman Topography in the University of Rome.

OUR knowledge of the progress of medicine and of the scientific value of medical men among the Romans rests more on the authority of classic writers than on the evidence of monuments connected with the *ars medica* lately discovered in our excavations. From this point of view the field is practically unexplored. Facts have been collected by Lancisi, Marini, Bernegan, Ackermann, Hebensteckt, Necker, De Mattheis, Brian, Marchi, Pericoli and by myself,* but they have yet to be brought together and compared with the results of recent discoveries. The "Esposizione d'Igiene," organized in connection with the present Medical Congress, contains many remarkable specimens illustrating the practice of medicine and surgery in ancient times, the sanitation of ancient cities, etc., but by far the greatest number of these objects lie still unknown in public and private collections. I have for many years advocated the institution of a central Museo d'Igiene for the exhibition and study of monuments pertaining to the cremation and inhumation of men, to the regulations of cemeteries, to drainage and water supply, to the sanitation of the Campagna, to



THE MEDICAL CONGRESS, ROME—THE LUNCH AT THE BATHS OF CARACALLA.

the worship of healing gods, to gymnasiums, baths, to the practice of surgery and dentistry, to hospitals, etc. The materials for the institution are all ready, and if we should require more, we know where to find them. It was customary in ancient times for persons cured of their ailments by the skill of priest doctors or by the value of thermal waters to put up a votive offering as token of gratitude to gods and men. Each sanctuary hospital, therefore, was furnished with one or more rooms for the exhibition and safe keeping of ex-votos. The walls of these rooms were studded with nails, on which ex-voto terra cottas or tablets were hung by thousands. When every inch of space was filled and no room left for the daily influx of offerings, the priest removed the collection and buried it either in the vaults of the temple or in trenches dug for the purpose. In case of a watering place the offerings were thrown at the bottom of the spring. Many such mines of ex-votos have been explored in recent times at Vicarello (*aquæ Apollinares*), at Nemi (*templum Dianæ, seu Artemisium Nemorense*), at Veii (*templum Junonis*), at Rome, in and around the island of S. Bartolomeo, where the Temple of Æsculapius stood. The discovery of the deposit of Vicarello took place in 1852. In draining the main spring for the purpose of cleaning it from incrustations which had nearly choked the orifice, the Jesuit fathers, to whom the place belonged, came across a layer of brass and silver coins of the fourth century after Christ. It was followed by a stratum of gold and silver coins of the empire, mixed with silver drinking cups on which various itineraries (from Cadix to the Springs) were engraved. The third layer was composed of Republican coins; the fourth of shapeless fragments of copper (*æs rude*); the fifth, at the very bottom of the well, of flint implements offered to the local god by the half savage people settled in that neighborhood long before the foundation of Rome. The exploration of the seam of ex-votos at Veii began two and a half centuries ago, at the time of Pope Alexander VII., and is not yet finished. The ex-votos from the local sanctuary of Juno were not buried in a *favilla*, but thrown from the edge of the cliff on which the temple stood into the valley of the Cremera. In 1889 I was able to make a rough estimate of the size of the deposit: 250 feet in length, 50 feet in width, and from 3 to 4 feet in depth—nearly 44,000 cubic feet. The vein contained fifty-two varieties of types—busts, masks, arms, breasts, wombs, spines, bowels, lungs, toes, genital organs, figures cut open across the breast and showing the anatomy, arms, legs, feet, etc. It is a great pity that these materials for a comparative study should have been scattered far and wide, and that no scientific or systematic search should have been attempted. Ample opportunity, however, is still left to mend matters and regain the time lost. The bed of the Tiber around the island of Æsculap contains superb specimens of anatomical preparations in terra cotta. The exploration of the springs of the *aquæ albulæ* has never been attempted, nor that of the lake Gabii. Tombs of surgeons and oculists abound in tools of the trade, or in recipes of various kinds. Skulls show occasionally curious evidence of dental operations. The exhibition held in the Palazzo delle Belle Arti in the Via Nazionale shows what can be accomplished in this line even in a short time.—*Lancet.*

* Lancisi: De Advent. Rom. Cœli Qualit. Marini: Gli Archiatri Pontificii. Bernegau: De Servi Medici apud Græcos et Romanos Conditione; Halæ, 1733. Ackermann: De Antonio Musa Augusti Medico. Hebenstreckt: De Medicis Archiatris et Professoribus. Necker: Storia Filosofica Antica della Medicina; Firenze, 1852. De Mattheis: Dissertazione sul Culto della Dea Febre. Brian: L'Assistance Medicale chez les Romaines; Paris, 1869. Marchi: La Stipe Sacra delle Acque Apollinari. Pericoli: L'Ospedale di S. Maria della Consolazione; Imola Galeati, 1879. Lanciani: Ancient Rome; Boston, 1887.

MICROTOMY.

THE art of microtomy is really the finest of all fine arts. Indeed, so exquisitely delicate is it that it would seem to have hitherto escaped even the subtile appreciation of the amateur, who rangeth where he listeth, knowing all things and believing all things. The public is unfamiliar with the name of the art; the fame of the microtomist is not noised abroad. Those who appreciate the little glass slips with "Cole Deum" thereon, the quaint motto of the elder Cole, are less in number than those who gather walking sticks or rejoice in the tracing of brasses, says the *Pall Mall Budget.*

Indeed, collecting is almost unknown, though why people should collect stamps and leave these things alone surpasses our imagination. A day will come, however, when slides for the microscope by the early masters who are even yet living will be as eagerly sought and fondly treasured as were ever book plates or violins. Pity it is they worked in Canada balsam, which has the trick of decay.

It is even possible that the reader needs to be told what this microtomy may be. It is, poor soul, the delightful art of cutting inconceivably thin sections of every conceivable substance. There is nothing one may not cut, save one's friends—your fingers always volunteer of their own accord, sooner or later; but some things are unlawful (as, for instance, the coin of the realm), and some are not convenient (as the tail of a live lion). Moreover, the thing cut must be mounted cunningly on a glass slip, for the end for which the section exists is to be examined under a microscope.

If one would see some microtomist's work, let him seek a medical student possessed of a microscope. The same will show him a number of glass slips three inches long, perhaps, by three-quarters wide. These will be labeled—one "Muscle;" another, "Sciatic Nerve;" a third, "Scalp of a Child;" and a fourth, "Cat's Liver." Such names do not lead one to anticipate art and beauty, and this makes the art and beauty all the more charming.

In the center of each of these slips, covered by an extremely thin circular disk of glass, he will see a little slice of matter, the size, perhaps, of the head of a tin tack or smaller, and so thin as to be altogether transparent. This is, let us say, your cat's liver etherealized by the microtomist. Under the microscope it has the air of a circular stained glass window; the "cells" of the liver form an interlacing tracery of golden pink, and the diverse blood vessels, of which there are three sorts, appear, if injected, as branching shapes of crimson, blue and other sweet and pure colors, even such as the Madonnas of the old masters wear. The scalp may be even more delightful, with its hair like stout brown masts, a greenish cuticle and sunset tinted sub-dermal tissue below.

It is obvious that with such an infinite variety of material the microtomist must needs have a great variety of instruments. Some things he cuts with a common razor in his hand; such must needs be of a firm consistency, neither flabby nor brittle. Some again—larger things—he cuts with a plane. Little things he cannot hold he embeds in wax or carrot or the pith of the elder, and so gets a fingerful that may be grasped and cut. A soft substance, such as human muscle, he hardens by the immersion of a lump of it in a suitable fluid; or he takes it fresh and almost living, and freezes it firm upon a metal slab by means of ether.

A rock is cut into thin slices by a lapidary's wheel, a rotating disk of steel made keen by rubbing diamond powder on the edge, and these slices are stuck to a piece of glass and gradually rubbed thinner and thinner upon emery powder of increasing fineness, and finally upon rouge. Powdery things like sand grains the microtomist overcomes by embedding in hard substances. He particularly dreads and rejoices over such brittle substances as coal. One would expect mere blackness of coal even at its thinnest, but there are certain coals from Scotland which, when cut, reveal myriads of little flattened cases of a streaky orange or lemon yellow color, the snore shed long since by the trees which perished to form our coal seams.

There are in London, perhaps, half a hundred or more human beings who live by this unknown art. One we know of plies his trade in a little den high above the roar of the Strand. He sits at his window facing the light, watch glasses and little shallow dishes full of stains around him, microscope and micrometer ready to hand, sometimes amid a heavy aroma of ether from the freezing microtome, and sometimes reminding one oddly of pine trees and wide mountain slopes, with the resinous smell of his Canada balsam. All about him are little bottles—innumerable little bottles—labeled "skin of toad," "orange pips," "pine inflorescence," "lancelet," "kitten's lung," "tumor," and the like, or, rather, unlike, some of them fit ingredients for the brew of the witch. One whole shelf presently catches the eye, labeled "Mrs. Webster," and in smaller letters the part of Mrs. Webster is specified.

He relates a grewsome story in a tone of pathetic regret; how this Mrs. Webster was a landlady of his

who died suddenly—"poor old lady"—and was "post mortemed" by a confidential friend. "So I took these little mementos," he says, waving his hand at the shelf. It is a grim and sordid fate for a landlady that she should be peculated by her own lodger and retailed at 6d., 9d. and 1s. a slice, according to the choiceness of the parts. But there are those who suspect our microtomist of having obtained his human material in a legitimate way from the dissecting room, and having created his Mrs. Webster for literary effect.

Still the jumble of matters in the corpulent little bottles upon his shelves remain odd enough; pickled organisms from the deep sea are side by side with scraps of plant, root and stem, and the mortal remains of a pet puppy; while a fruit that grew and ripened in a jungle in Borneo shares a bottle with some cubic inch of substance that was once part of the vestiture of a human soul in a London hospital. Sooner or later they will come to the knife edge and the glass slip. Our microtomist is, indeed, on the level of Shakespeare. All being pays its tribute to his art; he makes it clear and brilliant for us, using his stains and media not to hide but to display, making truth truer and the visible plain. His work is a veritable microcosm—a summary of the world.

The ordinary microtomists who cut sections for the medical students, as a rule, do little in the direction of cutting rocks. This has a special technique, and is practiced chiefly at the greater geological schools—at the Royal School of Mines, for instance. It is almost impossible to convey an idea of the appearance of sections of some granite rocks when seen in polarized light. Let the reader think of the tints of a film of gas refuse floating on water, of the spectrum thrown by a glass prism, of fire opal, of the mother-of-pearl, of old stained glass windows, of Burne-Jones at his best. All these, and more also, will he see in such a rock as picrite or dunite. A day will come when artists will seek these things and learn a thousand delights of coloring from their study, for microscopic sections may be collected for their beauty, for their technical excellence, thinness, and so forth, for their historical interest and for scientific importance.

ON THE ACTION OF ALUM UPON THE NERVOUS SYSTEM.

THE modern development of chemistry has undoubtedly been of the greatest possible service in arts, manufactures, and in medicine, but, like all good things, it is not without its disadvantages, and sometimes it may lead to evil, the cause of which may remain long unsuspected. It is possible that this may be the case with some of the nervous diseases whose causation is frequently attributed to hurry, worry, and nervous strain, due to an advancing civilization. There is no doubt that the introduction of the penny post, railways, and telegrams has very greatly increased the strain upon the nervous system, but still we can hardly attribute to them some of the obscure nervous diseases from which some people suffer, while a very large number more who are subject to the same strain remain uninjured. The number of the factors which may be concerned in producing nervous disease has hitherto rendered it impossible to trace these diseases to their exact source. Of late years there has been a tendency to recognize a likeness between the symptoms of certain nervous diseases and those produced by poisons; and, as Dr. Sidney Martin showed very clearly in his Goulstonian lectures, the paralysis which follows diphtheria is not due to the microbe of the disease, but to a poison produced by it which will cause nervous degeneration and loss of power when separated from the microbe and injected into an animal. The poison produced by the diphtheria bacillus appears to belong to the class of toxalbumins, but in his researches on anthrax poison Dr. Martin showed that from the anthrax virus an alkaloidal substance could be separated which had a lethal action like that of the ordinary virus itself.

In the Croonian lectures for 1889, Dr. Lauder Brunton pointed out the likeness between the symptoms of disseminated sclerosis and locomotor ataxy in man and those produced in frogs by poisons belonging to the benzine series, and such observations indicate the possibility of certain nervous diseases being caused by the absorption of poisonous products of albuminous decomposition in the intestines. Certain inorganic substances are well known to cause nervous disease, examples of which are lead palsy and mercurial tremor, affections which are readily traced to the poisons producing them. Hitherto, however, no attention has been directed to alum as a possible cause of nervous disease, and yet the symptoms it produces on the nervous system after its absorption into the blood are very remarkable indeed. They were apparently first noticed by Orfila, who found that when alum was given to a dog, and vomiting prevented by ligature of the gullet, death occurred, with symptoms of weakness and diminished sensibility, so that it was almost impossible for the animal to stand upright, and pinching or pricking caused no movement.

The most complete series of experiments on the action of aluminum salts were made under the direction of Professor Hans Mayer by Paul Siem. These experiments showed that when administered to animals (dogs, cats, and rabbits) by subcutaneous injection, a soluble salt of alum causes no symptoms at all for three or four days. Then the animal suffers from loss of appetite and obstinate constipation, emaciation, languor, and disinclination to move. Next there is vomiting and loss of sensibility, as a deep prick with a needle is scarcely felt. When forced to move the leg is raised, but trembles and twitches violently, and is with difficulty placed on the ground. Sometimes there is general tremor or convulsive twitching, and sometimes there is extreme weakness or partial paralysis of the posterior extremities. There is complete loss of sensibility to pain, while the animal retains its senses. Then the power of moving the tongue and of swallowing is completely lost; even the saliva cannot be swallowed. The symptoms are precisely those which are observed in a disease occurring in man, and known under the name of acute bulbar paralysis. The cause of this disease in man is at present unknown, and the idea of its possible connection with the continued absorption of alum in the same way that lead palsy or mercurial tremor may be due to the absorption of lead or mercury is quite a new one. Much observation may be necessary in order to ascertain whether such a connection exists or not, but the disease is so dreadful and its treatment so hopeless that it is worth while for physicians generally to try whether such a causal connection between the use of alumina and the appearance of the disease can be traced. It is probable that many medical men are unaware of the extent to which salts of alumina may be introduced into the body, because they are under the impression that the use of alum in bread is forbidden by law, and that, as this element hardly exists to any extent in any potable waters, they may consider that its introduction into the body is impossible.—*British Medical Journal.*

APPLICATION OF ANTISEPSY TO HYPODERMIC MEDICATION.

WHO has not seen, if he has not employed for himself, the morphine syringe, whose sharp needle, through a slight puncture, gives repose, calmness and sleep to the sick almost instantaneously? One might inscribe upon its case, as a motto: *Divinum est opus sedare dolorem.*

So many advantages are not unaccompanied with some inconveniences. Without speaking of the abuses that may follow a too prolonged use of it, it must be

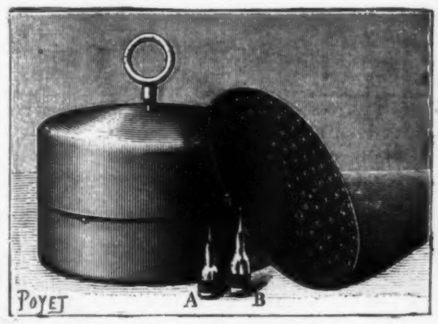


FIG. 1.—STERILIZED TUBES, A B, AND SILVER PLATED RECEPTACLE.

known that the germs that surround us, on every side, microbes and fungi and internal parasites, may invade solutions or develop in the syringe and its needle. Thus arise erythema, painful induration, abscess in light cases and phlegmon in grave ones, erysipelas and purulent infection.

In order to suppress such accidents, Messrs. Duflocq and Berlioz propose to combine the use of sterilized tubes with that of a quickly sterilized syringe. The tubes, which are made of yellow glass in order to prevent the action of the light, contain, some of them, half a cubic centimeter of liquid, and others a cubic centimeter.

They have the form of a small bottle (Fig. 1, A B). Fig. 4 represents them of natural size. Their slender neck is composed of two parts. The first, *c*, gradually tapers to *a*, where it joins the second, *e*, which is much more slender. At the moment of using, the breaking

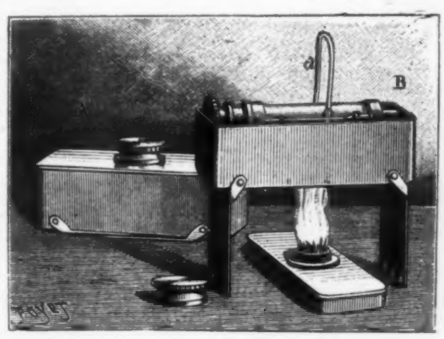


FIG. 3.—SYRINGE INCLOSED IN THE STERILIZING BOX.

A, apparatus closed; B, the same open.

is necessarily effected at the fragile point, *a*. Into the aperture thus formed it is necessary to introduce the needle of the previously sterilized syringe, to invert the tube in holding the syringe vertically, and to suck in the liquid. It then suffices to expel the air, and observing the graduation of the rod, to fix the quantity of liquid that one desires to inject.

For filling the tubes, a round vessel of silvered metal (Fig. 1) is used and into which is poured the accurately titrated solution, the vehicle of which is distilled water. Above there is placed a perforated metallic diaphragm into the apertures of which are inserted the slender neck of each tube, the point of which enters the liquid. The cover is put on and the whole is placed in a heating apparatus and left therein for twenty minutes at temperature of 120°. After cooling the apparatus is placed under a bell glass which is put in communication with an air pump, through whose operation a vacuum is created in the bell glass and in the tubes, the air in which escapes in bubbling up through the liquid. The air is afterward allowed to re-enter in filtering it through sterilized wadding, and the pressure of the atmosphere, acting upon the surface of the liquid, forces it to ascend into the tubes. These latter are then sealed, one by one, by means of a lamp. As all manipulation is suppressed, it will be seen that it is impossible, under such circumstances, that the solution shall be contaminated at any moment.

These perfectly aseptic tubes are therefore capable of being preserved for an indefinite period. Thus it will be possible to prepare all the solutions employed in hypodermic medication: morphine, which suppresses pain, caffeine, which excites a weak heart, ergotine, which arrests hemorrhages, cocaine, which renders the skin insensible locally and permits of performing simple surgical operations, ether, which excites the nervous system, quinine, which reduces fever, etc.

A physician carrying some of these tubes about with him may immediately deal with the most pressing contingencies of his practice. The tubes are preserved in a zinc box, which is capable of holding a large quantity of them (Fig. 2).

The syringe, which is wholly nickel-plated, does not exceed the ordinary hypodermic one in volume (Fig. 3). It is composed of two parts: the one that forms a cover is an alcohol lamp, while the other is a box provided with feet that fold up under the bottom and containing, upon a special support, the syringe and the needles, B (Fig. 3). Without aid and without having need of anything else but a large glass of filtered water, one can effect the sterilization of the syringe in a few instants. When it is desired to use it, it is taken from the box along with the support. In order to fill the syringe with water, which is indispensable, it is necessary in the first place to pull out the piston rod to the end of its travel, and then to plunge the entire syringe into a glass of filtered water and then to push the rod in. Through this maneuver the water enters

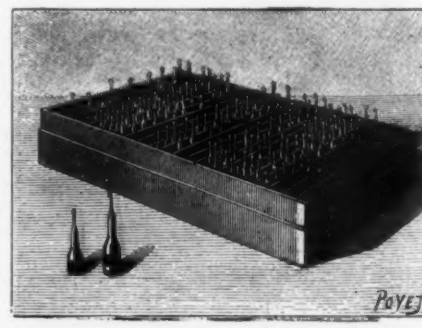


FIG. 2.—ZINC BOX CONTAINING THE TUBES.

the entire body of the cylinder above the piston in infiltering from above on every side of the rod.

The latter is finally drawn out a few millimeters, in order to suck in a little water beneath the piston. The syringe thus prepared is placed upon the support and the latter is put into the box, which is large enough to hold the syringe with its rod slightly extended. The feet are unfolded and enough filtered water is poured into the box to cover the syringe and needles. The small lamp, having been lighted, is placed between the feet (Fig. 3). In three minutes ebullition takes place, and is kept up for two minutes. It remains to take out the syringe, to expel the water that it contains, and to fill it by means of a sterilized tube.

Thus, then, through the use of this method, in which everything is sterilized—the syringe, the needles, and the solution—the invalid will, without fear, be able to receive the puncture which always relieves, often cures,

FIG. 4.—STERILIZED TUBES, NATURAL SIZE.

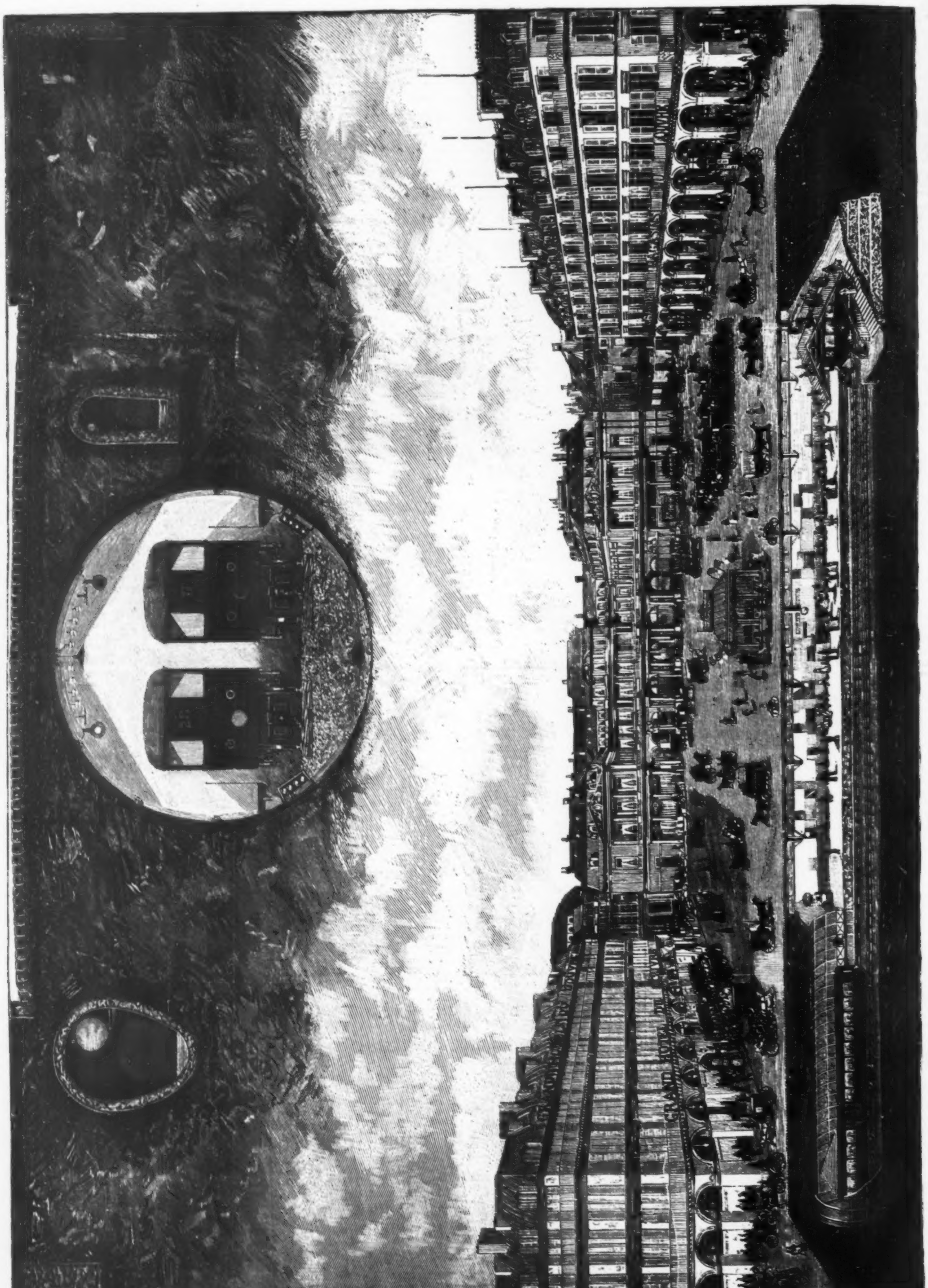
and sometimes, even, may perform miracles in desperate cases.—*La Nature.*

WATER VIBRIOS.

ACCORDING to the studies of Sanarelli, the idea of the morphological unity of the cholera bacillus must be abandoned, since there exist different varieties of vibriones morphologically distinct, which are capable of producing in man and in the lower animals one and the same type of cholera, clinically identical. Koch's bacteriological diagnosis of cholera, as recently established, agrees neither with the idea of a limited monomorphism nor with the assumption of a polymorphism of the vibriones, since in every impure water we may find pathogenous microbia which possess quite the same characters as the specific exotic vibriones. In addition to the morbific forms originating in the water, which exactly resemble those from the bowel, there are found in water a number of non-pathogenous microbia which approach the former very closely, so that they may be regarded as varieties capable, under certain circumstances, of resuming their former (?) malignant properties. This constant occurrence of pathogenic microbia in all sewage is a proof of the great importance of the pollution of water for the origin and the spread of cholera. The water vibrios and those of cholera dejections are in every respect very closely allied, which points to a common origin. Virulent water vibriones do not long retain their malignant character; they gradually disappear along with the other characteristic properties of the vibriones, such as the formation of nitrites and of indol.—*Annales de l'Inst. Pasteur and Chemiker Zeitung.*

THE TUBULAR RAILWAY OF PARIS.

SINCE the twenty years that it has been upon the carpet, the question of an elevated railway, ever pending and never solved, has periodically aroused in the public a ray of hope, soon followed by a new deception.



THE TUBULAR RAILWAY OF PARIS.

1. Section of the tunnel under Rue Saint Antoine. 2. View of the Palais Royal station.

The certainty that, in default of an elevated railway, we are going to have a subterranean tubular tramway line between Bois de Vincennes and Bois de Boulogne has recently been received with joy.

The project for the establishment of it, submitted by Mr. Berlier, its author, to the city of Paris as long ago as the first of September, 1887, was successively examined by the Administration and the Municipal Council. Postponed in 1888 for further study, it was resumed three years later, and on the 25th of July, 1891, the council, upon the report of Mr. Sauton, decided to submit it to an inquiry as to its public utility. Such inquiry was entirely favorable, despite a few interested objections of the omnibus company and of a competitor, the author of a rival project.

The projected direction line will burrow the subsoil of the following public thoroughfares: driveway of Vincennes, Place de la Nation, Boulevard Diderot, Rue de Lyon, Place de la Bastille, Rues Saint Antoine and de Rivoli, Place de la Concorde, Avenue des Champs Elysées, Place de l'Etoile, Avenues Victor Hugo and Bugeaud, ending at Boulevard Flandrin. This line will be one of 6·6 miles.

What particularizes the Berlier project is, in the first place, the construction of the railway by pushing it forward underground without opening wide trenches in the public thoroughfares, the use of metal for lining the sides of the tunnel, and, finally, the exclusive use of electricity for the propulsion of the vehicles and the internal lighting of the tunnel and stations.

At the time of the deposit of the project, these innovations were earnestly discussed. Was it possible, in fact, to establish underground, that is to say, without an opening upon the public thoroughfare, a metallic tube, 19 feet in diameter, designed for the running of trains therein, and would not the execution present insurmountable difficulties?

The experiment has now been made, and the delegation of the Municipal Council sent to London three

years ago saw two three-and-a-half-mile subterranean lines established according to these principles and which were operating in the most satisfactory manner.

Although the tunnel can be established throughout its entire length by subterraneous excavation, the same is not the case with the stations and the junction parts in masonry. Here another method of work will be employed, but one that will not interrupt travel during the execution of it. To this effect, the arrangements made by the service of public thoroughfares at the time of the reconstruction of the street pavements have suggested themselves.

At each station a foot bridge connecting the platforms of the outgoing and incoming trains will be installed at the upper part of the tunnel, so as to have but a single stairway debouching upon the thoroughfare. It may be considered that the construction of such stairways will not be accompanied with any more inconvenience to the public than that of any sewer branch whatever. Such inconvenience will be still less if these stairways are placed in lands adjoining the line where too great a travel or insufficiently wide sidewalks would not permit the grantee to establish a structure upon the street. The Commission of Inquiry of the Municipal Council pronounced itself formally against any building upon the public way in the center of Paris, between Place de la Concorde and Place de la Bastille. The same would not be the case upon the wide sidewalks, avenues or places, such as Place Victor Hugo and Avenue des Champs Elysées. It is not a question, however, in this case, of establishing true offices in which the employes and the public would be called upon to remain momentarily. The kiosks constructed will be simply designed to close the passages and the stairways that allow the public to reach the subterranean railway.

The method of construction that we have indicated will be applied to all the stations save that of the Bastille, which will be an open one constructed upon the basin of the arsenal. This station will have a monumental character that will contribute to the aspect of the place. Conformably to the wish long ago expressed by the service of public thoroughfares, the place will be widened at the exit of Rue de Lyon. To this effect the basin will be covered throughout its extent, and the station will be established at twenty feet to the rear of the present parapet, where are now located the termini of the Porte Rappe and Montparnasse tramway lines.

It remains for us to examine the use and the role of electric propulsion. The efficacy of this is not discussed. It is demonstrated to-day by the City and South London Electric Railway, which was visited by the delegation of the Municipal Council during its stay in London, and which carries thousands of passengers daily. It will be seen that in this innovation, as well as in several others, Paris has been distanced by English capital, with which the results obtained are of a nature to reassure Parisians, and especially the ladies, who might experience some mistrust in regard to the new mode of locomotion.

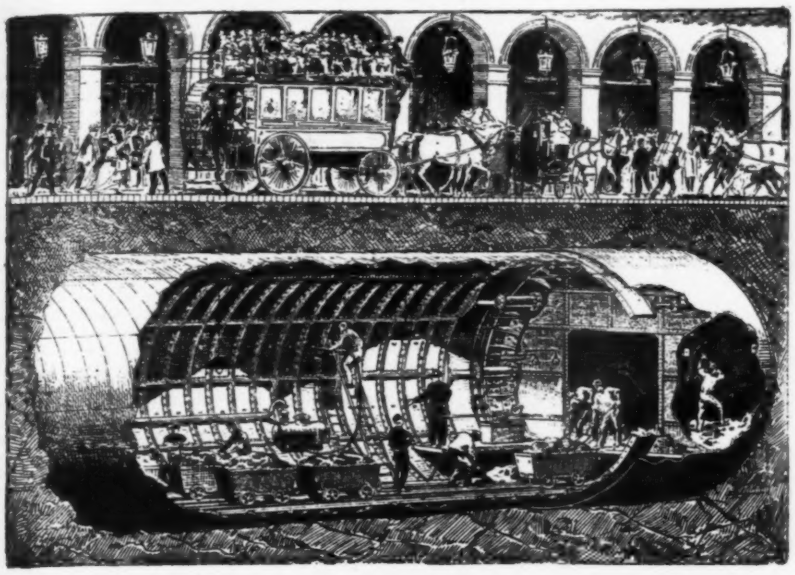
The following, in a few words, is the mechanism of the electric propulsion employed by the Berlier system. Between the rails there runs a conductor of rectangular section isolated from the ties by blocks of glass. This conductor is supplied by feeders that start from the main copper cables, which are insulated in a rubber sheath inclosed in lead and connected with the sides of the dynamos of the electric plant. The rails form the return conductor.

A few words as to the manner in which the author of the project intends to assure the service of the line, and as to the peculiar arrangements of the vehicles, will interest our readers.

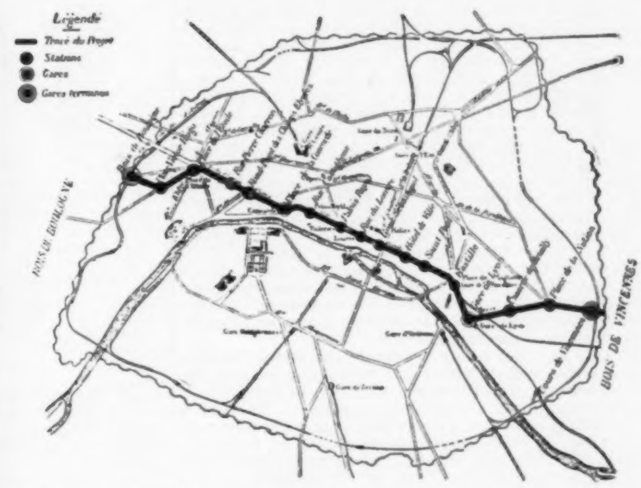
Each train will consist of one, two, three or four cars each, with a seating capacity for fifty-two passengers. The speed will be about twelve miles an hour. The total duration of a complete trip, including stoppages at the stations, will be 37 minutes and 33 seconds. At each of the 15 stations a stop of 20 seconds will be made, say, in all, a stop of 5 minutes. The trains will, therefore, make the entire trip of 6·6 miles in 32 minutes and 33 seconds, exclusive of stoppages. The cars will be entered at the sides, as in railway cars. The floor of the compartments will be on a level with the station platforms. Ordinarily, the trains will follow each other at two minutes interval upon a portion of the line (from Place de la Concorde to the Lyons station) and at four minutes upon all the rest. Upon days of fetes, races and reviews, in which the influx of passengers is greater, the number of the trains will be easily increased. The Berlier project presents two improvements upon the London Subway. In the first place, instead of being established under ballast, which produces a deafening noise when the cars are under way, the two tracks of 3·28 foot gauge will rest upon wooden ties embedded in ballast in order to deaden the noise. In the second place, the ventilation of the tunnel will be better assured. As electric propulsion disengages neither gas nor smoke, no attention whatever has been paid in London to ventilation, and no special measure has been taken in regard to it. Here, on the contrary, the tunnel will be ventilated by means of draught chimneys, starting from the summit of the tube and connecting with the interior of the structures placed upon the sidewalks. Let us now examine the question of fare, which especially interests the population of Paris. Mr. Berlier at the outset requested that the price of seats should be fixed at 6 cents for the first class and 3 for the second, but in the train of the observations of the lamented Mr. Alphand, he accepted the single price of 4 cents for a single class, whatever be the distance to be traveled. The third commission of the Municipal Council, by a vote of 6 to 5, did not, despite the opinion of the reporter, think it its duty to agree to these latter propositions, and pronounced itself in favor of two classes.

Let us hope that the Municipal Council will not persist in such a view, since, to point out but a single advantage of one fare, the public would find itself freed from the irksome obligation of standing in a line at the first wicket in order to get a ticket to be punched by an employe before entering the car, and, finally, on arriving at his destination, of presenting this ticket again to a third employe.

It would suffice for the passenger to deposit his fare



EXCAVATION OF THE TUNNEL UNDER RUE DE RIVOLI.



DIRECTION LINE OF THE TUBULAR RAILWAY BETWEEN BOIS DE BOULOGNE AND BOIS DE VINCENNES.

PLACE DE L'ETOILE STATION.

THE TUBULAR RAILWAY OF PARIS.

in the orifice of a turnstile, which would mechanically control his right of access to one of the cars of the first train to start. The loss of time thus avoided would be an advantage so much the greater in that the trains having to succeed each other at two minutes' interval, the least retardation would be reflected upon the entire line.

Such, in its broad lines, is the economy of the tubular railway, whose realization is awaited by the Parisians with so much impatience. According to Mr. Berlier, the road will be finished and in operation during the course of the year 1898.—*Le Monde Illustré.*

IMPROVED STEAM TURBINES.

THE steam turbine seems to be attracting very considerable attention at present, judging from the numerous patents being applied for, chiefly by electrical engineers.

The Parsons turbine is an acknowledged success and is doing good work, and we recently described the De Laval turbine, which also seems to succeed. The Morton steam turbine was the subject of a paper read by Mr. Morton before the Glasgow Society of Engineers and Shipbuilders. It is based on the reaction principle, if we accept the author's statement, but the fixed curved blades look very like guide blades, and according to Rankine a reaction turbine is a turbine without guide blades. We rather think, if the nozzles were fixed, and these curved blades allowed to revolve, the results might be better. The author admits that the action of the jets against the blades is equal, and opposite to, the reaction in the nozzles. If that is so, why not fix the nozzles and revolve the blades, and thereby make a simpler engine without all the packing rings and making the lighter part the moving part? However that may be, this turbine is a valuable contribution to the class, and we give the following extracts from the paper read upon it by the inventor himself, with sections of the turbine.

We may say that many years ago the steam turbine question was well thrashed out by engineers, and the patent records contain scores of ideas on the subject, some worked out and some only proposals. The paper is devoted chiefly to a description of some improvements recently made on the oldest engine we have any account of in history, viz., the revolving eolipile of the ancients, described by Hero, of Alexandria, in the second century B. C.

This improved engine, and dynamos to suit, were made, and the drawings, Fig. 1 and 2, represent it. Fig. 1 is an end section, showing on the left of the vertical central line one-half of the first or outward flow wheel, and on the right of the same line one-half of the inward flow wheel.

The casing, A, of this engine has only one simple compartment, Fig. 2, the casing being one casting, with two end covers bolted there o, inclosing two distinct and separate wheels. The first wheel, B, has three rings, 1, 2, and 3, of outward flow nozzles of different diameters. The first or smallest ring is 9½ inches, the second 12¾ inches, and the third 15 inches diameter, thus forming annular spaces between the rings. The second wheel, B, has two rings of inward flow nozzles, 4 and 5. The larger ring is 15 inches, and the second, or inner, 12¾ inches, diameter, thus forming an annular space between the two rings, into which spaces the curved projections, F and F', are fitted. Both wheels are mounted on the same shaft, D, and inclosed in a single compartment casing, A. The higher pressure steam enters the first wheel, B, by an annular opening around the shaft, D, as shown by the arrows (Fig. 2), and travels outward through the first ring of nozzles into the first annular space between the first and second rings, and flows out through the nozzles of the second ring into the second annular space, and from thence outward through the third ring of nozzles into the casing, A, which is common to both wheels.

The steam returns from the casing, A, flowing inward, first through the larger ring of nozzles, 4, into the annular space between the rings, and in through the second ring of nozzles, 5, toward the center of the inward flow wheel, B_1, thence through the exhaust annular opening around the shaft, and by the branch to the condenser.

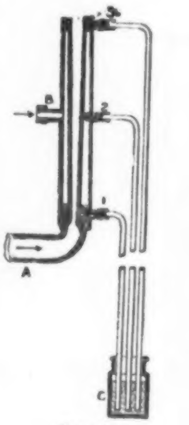


FIG. 5.

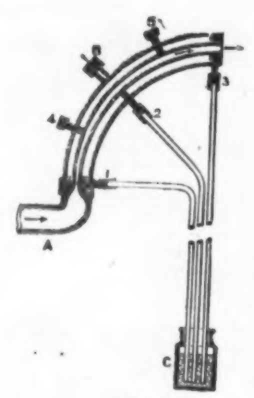


FIG. 6

At each ring of nozzles the combined area of these openings increases as the steam becomes reduced in pressure. The first ring of the series has eight, $\frac{1}{16}$ inch by $\frac{1}{2}$ inch, and the last ring ten curved nozzles, $\frac{3}{8}$ inch by 1 inch, and there are only five stages of expansion in this engine. The steam issuing from the curved nozzles in a tangential direction tends to circulate in a contrary direction to that in which the wheels may be revolving, to prevent which a series of curved projections, E, are cast or fixed on the interior of the casing, A, for the outward flow current, and another series, F, are cast on or fixed to centrally fixed disks, H, in the interior of both the outward and inward flow wheels, so as to arrest the outward and inward flow currents. These projections are more clearly shown by the enlarged sections, Figs. 3 and 4.

Fig. 3 is an enlarged section of a segment of the casing, A, inclosing a segment of the outward flow side of the wheel. The curved projections, E, are shown cast on the interior of the casing, A, to prevent circulation therein, and Fig. 4 is a similar segment of the casing, A, inclosing and showing in section a segment of the inward flow side of the wheel, B. The curved projections, F, in the interior of the inward flow side are cast or fixed on a central stationary disk, H, supported by its central trunnion passing out through the wheel, and fixed in the partitions.

To describe the numerous experiments, with different forms of nozzles, before the form shown on the drawings was adopted, would require a paper on that subject alone; but the two experimental apparatus shown by Figs. 5 and 6 are so important to this paper that they cannot well be left out. Fig. 5 is a full size section of an apparatus constructed with a central cylindrical tube $\frac{1}{16}$ of an inch wide at the narrowest part, or throat, tapering to $\frac{5}{8}$ of an inch at the mouth. The tube is 10 inches long, and has three small branches, 1, 2, and 3, communicating, by very small holes, with the interior of the tapered tube. To these branches, 1, 2, and 3, three bent glass tubes are coupled by short pieces of India rubber tube, and these glass tubes reach down to near the bottom of a dish of mercury, C.

The apparatus is bolted on to a branch steam pipe, A, with the throat end next the supply steam branch, all as shown by Fig. 5, ready for experiment. On opening the stop valve so as to admit steam to the supply branch, A, it flows through the throat of the apparatus, and is freely delivered into the atmosphere at the mouth or wider end, and the effect is shown by the mercury rising in the glass tubes connected with the branches, 1, 2, and 3. The mercury in No. 1 rises highest, that in No. 2 next, and that in No. 3 scarcely any, showing that a partial vacuum is maintained throughout the whole length of the tapered discharge tube. In case the naked tube should in any way affect the experiment, it was inclosed within a parallel brass tube and soldered, so as to leave a free space all round.

Steam was admitted into this annular space by the branch, B, so that the central tapered tube was incased with steam of a higher temperature than that passing through it; but on again performing the experiment, practically the same result was obtained, viz., a partial vacuum throughout the whole interior of the tapered tube, the vacuum being greatest near the throat.

Another experimental apparatus (Fig. 6) was made in form of a bent tube, tapering from $\frac{1}{16}$ inch by $\frac{3}{4}$ inch at the throat to $\frac{7}{16}$ inch by $\frac{3}{4}$ inch at the mouth, incased in a larger tube, and soldered steam tight. The branches, 1, 2, and 3, communicate with the mercury dish, C, as in the previously described experiment, and those branches, 4 and 5, with pressure gauges. The acting steam is admitted by the branch, A, and the incased steam by the branch, B.

On performing the experiment, it was found that a partial vacuum was maintained all along the lower or convex side, and a partial pressure all along the upper or concave side of the incased bent tube; there is, therefore, a partial pressure on the concave side and a partial vacuum on the convex side of a tapering bent tube at the same instant of time when high pressure steam passes freely through it into the atmosphere, and this is the form of nozzle which has been adopted, and shown more clearly on the enlarged scale drawing, Figs. 3 and 4.

It would seem from those experiments that steam issuing freely from an orifice, without admixture of air or other vapor by induction, expands very little, if any, laterally when free to expand on end, thus behaving very similar to that of liquids—such as water under the same circumstances.

In concluding this paper, a few remarks as to the efficiency and uses of this reaction engine would be useful. The engine, coupled direct with the dynamo (Figs. 1 and 2), has only two compound wheels, and when both were in place, with a given weight of steam, this engine developed 11·0 electric or brake horse power, and when the low pressure wheel was removed, and the high pressure wheel alone in place, the duty, with the same weight of steam, fell off to 6·5 B.H.P.; and with the high pressure wheel removed, and the low pressure wheel replaced, 4·5 B.H.P. was given, thus agreeing with the experiment when both wheels were in place, 6·5+4·5=11·0 B.H.P.

In March last, Dr. Archibald Barr and Mr. Henry A. Mavor, of the firm of Messrs. Mavor & Coulson, electrical engineers, made a joint series of experiments on the engine represented by Figs. 1 and 2, and from their report the duty—with 78 lb. per square inch, above atmosphere, initial steam, 20 inches vacuum, the engine developing 10·16 B.H.P.—required 87 lb. of steam per B.H.P. per hour, with feed water at the low temperature of 40·3° F.—*The Electrical Review.*

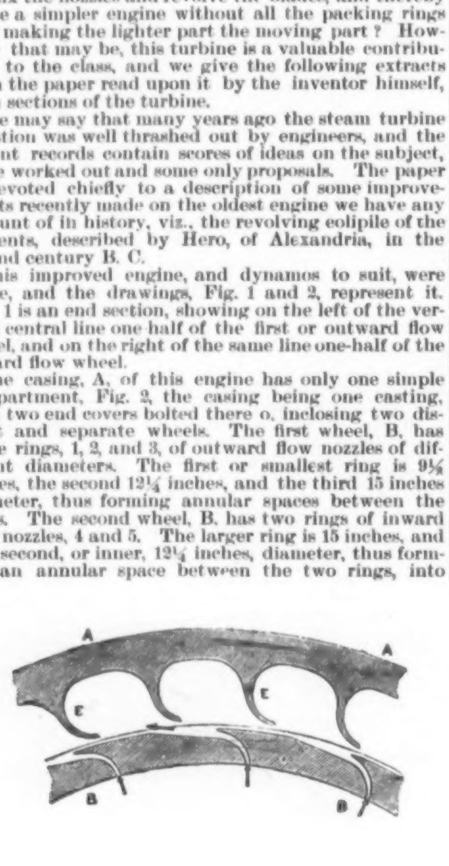


FIG. 3.

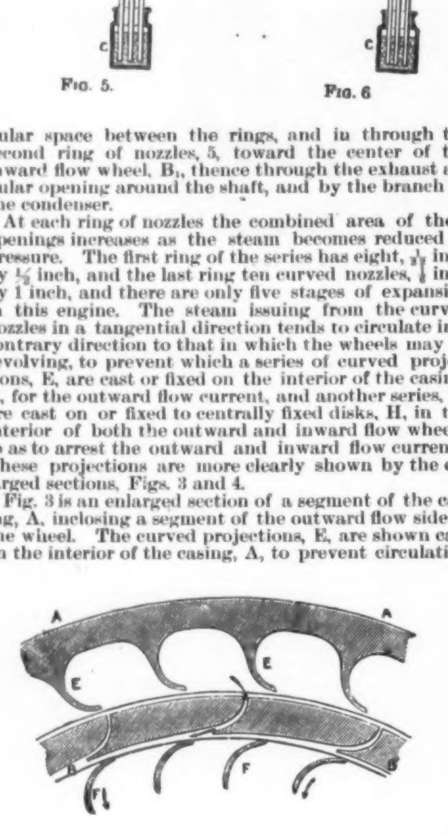


FIG. 4.

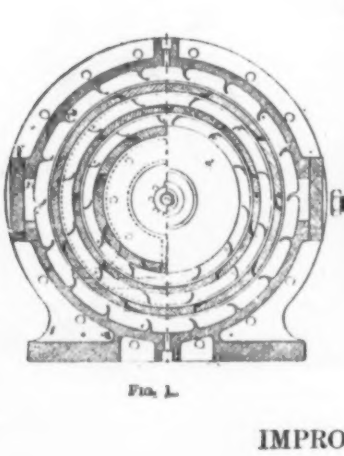


FIG. 1.

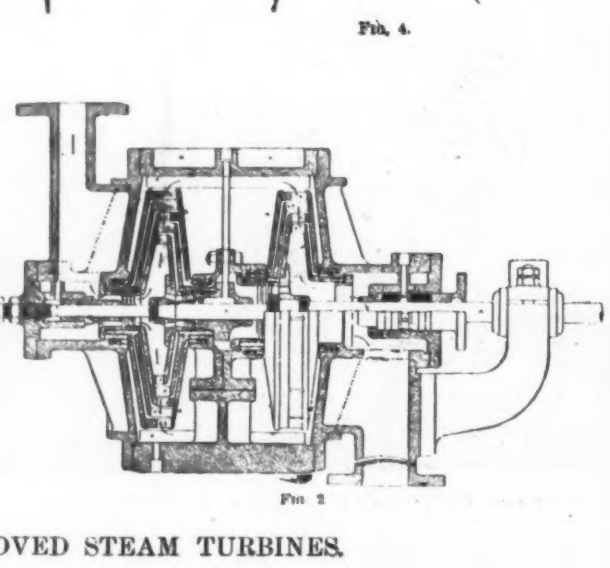


FIG. 2

IMPROVED STEAM TURBINES.

LUBRICATION.

AT the February monthly meeting of the Birmingham Association of Mechanical Engineers a paper was read by Mr. H. Rallings on "Lubrication." The lecturer first called attention to friction, that familiar resisting force which always acts to prevent or retard the relative motion of one particle or body in forced contact with another. There are three kinds: sliding, rolling friction acting between solids, and fluid friction acting between particles of liquids. Friction, whatever kind considered and whatever its cause, always results in the conversion of an amount of energy measured by the work of friction into heat. This production of heat occurs in every case in proportion of one British thermal unit for each 772 foot pounds of work absorbed by friction. The amount of heat produced may therefore be calculated by dividing the total work of friction for any given case by this "mechanical equivalent of heat." Thus one horse power expended in friction results in the conversion of work or energy into British thermal units per minute. For example,

$$\frac{33{,}000 \text{ foot pounds}}{772} = 43 \text{ B. T. U.}$$

The friction of solids was dwelt upon, and attention was called to the necessity of smoothness of bearing surfaces, the proper space to leave between shaft and bearing, just to allow of proper flow of lubricant, the length of journals in proportion to their diameters, and several hints how to convey the lubricant to reduce the friction. He next dwelt upon the lubrication

best suited for the surfaces above referred to, taking as his model machine "man," noting that all joints of the body were supplied with an oily fluid, "synovia." The glands being supplied with blood vessels, and the blood passing through them, they select properties and convert it into this oil for lubrication; the greater the exertion or hard work on these joints, the greater the flow of oil. The viscosity of the lubricant played an important part. If the load forcing in contact the surfaces were not kept apart by a lubricant of right viscosity, a partial rubbing of surfaces is the consequence, causing a heated bearing, which is oftentimes believed to be due to neglect or other causes. If the body of the lubricant is in excess of the force working on the surfaces, the friction is practically *nil*. The lubricants are of three classes—solids, semi-solids and liquids. He saw no necessity to call their attention to solid lubricants, or to the semi solid lubricant, although in many cases doing good work when well attended, but particularly called the attention to the liquid lubricant. He said the liquid should have at least five important points: (1) Enough body or viscosity to keep substances between which it is interposed from coming in contact under maximum pressure; (2) the greatest fluidity consistent with preceding requirements, *i. e.*, the least fluid friction; (3) the maximum capacity for receiving, transmitting and carrying away heat; (4) the entire absence of acid or other properties liable to injure the material with which they may be brought in contact; (5) a high temperature of evaporization and of decomposition.

Oils should not be liable to decomposition by heat or wear; the quality of the oil is usually of more importance than the quantity. Sperm oil is one of the best known lubricants, but its high price precludes its use. Other oils are cheaper, but have less lubricating power; others are good reducers of friction, but do not wear well. Castor oil is one of these; others gum so seriously that they cannot be used. Some cannot be used at a low temperature, because they congeal; and others cannot be used to lubricate steam cylinders because they decompose. He advised every user of lubricants to resort to some method of identification of the material by giving some method of testing it and ascertaining whether under the conditions in his practice it will serve his purpose.

The best lubricants are the following for usual conditions met with in practice, under very great pressure with slow speed: Graphite, soapstone, tallow and other greases. Under heavy pressure and high speed: Sperm oil, castor oil and heavy mineral oils. Under light pressures and high speed: Sperm, refined petroleum, olive, rape and cotton seed. Ordinary machines, lard oil, heavy mineral and other vegetable oils. Steam cylinders, heavy mineral oil. Having called attention to the lubricant best suited for bearings usually to be met with in engineering, attention was next called to the necessity of special lubricants for cylinders, especially under the high pressure of steam now in use and the heat that severely tries the oils used in gas engine cylinders. The lubricant specially set forward as best suited for such was that treated by the system of superheated steam to 1,400 Fah. The oils treated by this heat are mineral oils, sometimes called hydrocarbon oils, the process driving off the volatile oils; it is then repeatedly filtered through charcoal, etc., until all solids are removed without the original structure of the oil being in any way damaged.

This class of oil, although dearer than the black oils in use, is much cheaper in the end, when it has been proved again and again that by the sight-feed cylinder lubricators that are now so perfect that as few as two spots per minute will be ample to lubricate an engine of 200 horse power. Having treated all points in cylinder lubrication, he turned his attention to some of the ways the lubricant was applied to ordinary bearings. The wick feed was shown as having good points, but in the hands of careless attendants the wick could be fitted too tight and prevent the supplying of oil from the reservoir. The needle lubricator has great advantage over the other, because it was automatic and was one that could be seen by any one, whether full or empty, preventing guesswork; but these also in the hands of careless men could remain inactive, if the body of the oil was greater than the space allowed for its steady flow. A change of oil causes these to require a little adjustment.

The next best is the sight feed spotting lubricator, where the oil, whether thick or thin, can be spotted at any desired speed; the oil can be caught and set aside for other purposes. The best form is the bearing known as "Mohler's" self-lubricating; this is also known by the name of "patent bearing." It has a well of oil, and the collar in the revolving shaft lifts the oil by capillary attraction, and when at the top a spreader in the cap spreads it over the whole length of the bearing, and will do this for one month with one charge of oil, so is always in action and requires no attention day by day as others do. Some bearings, especially large main bearings of engines and main shafts, where oil is pumped in a continuous stream with small revolving pumps, this is exceedingly good, but only applicable to heavy work. He next devoted some time to semi-fluids for solid oils, also how they were chiefly used, the special forms of lubricators to use this grease, but was particular to point out that, although in some instances these greases were doing good service, yet there was not the automatic and reliable feed as there was with liquid oils. He most strongly urged the members that had under their charge large plants requiring lubricating to read Prof. Thurston's work, "Friction and Lost Work;" to this valuable work he is indebted for much help on lubrication. He quotes that Prof. Woodbury reports an instance out of several where a gain of power of 33 per cent. was effected by a change of grease for a light oil, the loss in cost of lubricant being comparatively unimportant.

Attention was called to reserving all used oils and filtering them, and using over and over again. Also to a simple test to prove the good and bad oils. In conclusion, he trusted that what had been placed before them would assist them to decide on the lubricant, whether for heavy or light work, and that it be the best consistent with price, and to give the preference to oils that will not char or gum, and to be sure to see oil tested from bulk is same as sample supplied, and that for cylinders to have the best mineral oil money can procure, especially as it is for so vital a part, to decide upon good lubrications such that can be seen in action, then something will be done to assist in saving coal and labor and satisfy yourself that you have given special attention to one important matter, "Lubrication."

WASTE ENERGY.

By GEORGE HILL, M. Am. Soc. M.E.

THE amount of energy which is constantly being given off without doing any measurable, useful work may justly be said to be far beyond all conception. Even if we limit the field to the so-called wastes which occur in one city, measuring simply those of which we have knowledge, the total expressed in figures would be something astonishing. But leaving broad generalizations, leaving the question of utilizing the heat of the sun's rays, or recovering useful work from the potential energy stored up by the tons of water that the fleecy clouds carry through the air, or in the tides ever ebbing and flowing, or in the waves of the ocean, could we harness any of them, let us see what it costs to use present appliances under ordinary conditions.

In order to be able to express results in intelligible form, let us assume the case of a fifteen story office building, 50 by 100 feet, standing on the corner of a street, the stories being all above the street level, and the basement being devoted to the power plant. The entire building and its plant would be designed in accordance with the best modern practice, with electric light, hydraulic elevators, exhaust steam for heating, etc.

The mechanical work required to be performed in a building may be said in a general way to be lighting and heating it, and to elevate its occupants to the points to which they desire to go, and also to lower them from these points. The amount of work actually required to be performed is, first, an expenditure of a certain number of foot pounds of work for heating, which may be most readily expressed in tons of coal. We would have to make good losses by radiation through walls, windows, floors, roofs, etc., and would have to warm the entering air required for ventilation. For the purpose of the present case it may be assumed that all this would require, say, 85 tons of coal a year, or 2,125,000,000 heat units.

Taking the year round, there would be required for the lighting of such a building as is here in mind about 1,000,000 lamp hours, this assumption being based on a lighting capacity of each lamp equivalent to 16 candles. This converted into coal, on the assumption that each pound contains 12,500 heat units, and that one candle power is equivalent to 0·0688 heat unit per hour for 100 per cent. efficiency, based on data obtained from the arc light, gives the number of tons as 0·044. For elevating the requirements are, of course, zero, since if we had an elevator of perfect efficiency, and a method of storage of perfect efficiency, we could, as soon as we had stored up enough energy to do one day's work, go on forever, the energy expended in elevating people being stored up again when they are lowered, and the energy required to start the car at the landings being made up by the energy given out when it was stopped. From this it will be seen that if we had machines of perfect efficiency, we should be able to perform all of the mechanical services of one of our large buildings with an expenditure of 85·044 tons of coal.

To determine what the wastes would be in this building we must convert the potential energy stored up in the coal into useful work. Various methods have been proposed of accomplishing this, but the limitations imposed by cost, convenience of manipulation, usage, etc., all point toward the steam engine. I would not be considered as in any way decrying the vast amount of human ingenuity which has been expended thereon, but I cannot but feel that it is very unfortunate that our development should have taken place in utilizing the expansive force of steam rather than in some other way, as will be hereafter noted. In the first place, the present use of coal involves a loss at the outset, due to waste in the mine, waste in its preparation for the market, waste in transmission and waste in useless combustion, these combined wastes amounting to probably two pounds of coal for each pound used.

Taking the steam engine in its most efficient form, we would have, where it is non-condensing, between the limits of 14·7 and 300 pounds pressure absolute, an efficiency of about 23·4 per cent., this being found by dividing the difference between the absolute initial and final temperatures due to the pressures assumed, by the absolute initial temperature. If we take the practical limits of 120 pounds of initial pressure and 5 pounds back pressure, we would have an efficiency of 15 per cent., which corresponds to a consumption of coal of 1·33 pounds per horse power per hour, and it is on this basis that we must calculate the generation of all power required for our electric lighting.

At the present state of efficiency of the art of electric lighting, we can, as a practical thing, obtain about twelve 16 candle power electric lamps for each horse power. This would make necessary the generation of 85,000 horse power hours annually. Should we attempt to gain so high an efficiency, as above noted, we should have to run the engines constantly, and therefore often very much underloaded, since the lighting duty varies constantly, both during each hour and during the day, with a consequent high friction loss. If, on the other hand, we adopt a proper subdivision of engine capacity, we should have a lower efficiency, so that it will be but fair to assume that, adding the inevitable losses in the piping, in the cylinder of a good engine, etc., we would have 170,000 horse power hours as the amount of work required to be performed, which means the annual consumption of at least 113·5 tons of coal. Subtracting the net number of tons heretofore given for lighting from the above, and also subtracting the 85 tons required for heating, leaves a net waste of 28·5 tons. It might be said that gas could be more effectually used as an illuminant than electricity, which might be true, were it not that with gas at any price that you please per thousand, 20 feet will give but 80 candles if burned as an illuminant, while the same number of feet will give 160 candles if burned in the cylinder of a gas engine used for driving an electric generator, as an average for everyday practice.

These facts are sufficiently discouraging, but the worst of all is yet to be faced. When we come to elevating we find, usually, the hydraulic machine employed. This machine is simply a hydraulic cylinder with a piston working in it, which carries on the end of its rod one or more multiplying sheaves, over which the hoisting rope passes. Water under pressure is admitted on one side of the piston only, to elevate the car, which, by gravity, discharges this water on its down trip. It will be seen, therefore, that the number of trips made per day determines the amount of water consumed, quite regardless of the amount of energy required. The elevator cars are sometimes made of 1,500 pounds capacity, and range from that to 2,500 pounds, and are counterweighted within about 500 pounds, so that we should have about 2,000 pounds as the load. If the car runs at a speed of 450 feet per minute, and runs but one-third of the time, it would have an average speed of 150 feet per minute, and since it elevates only one-half of the time, the average speed throughout the entire day would be equivalent to 75 feet per minute, and since, further, there are in an office day, roughly, 500 minutes, we would have a total travel of 37,500 feet. This, multiplied by four, for the number of cars, and 2,000 pounds for the load lifted, the amount of water required to fill the cylinder being always the same, regardless of the load, gives a total of 300,000,000 foot-pounds per day.

If we assume that the pumps which are employed convert the energy in the coal into work at about the rate of 25,000,000 foot-pounds per 100 pounds of coal, which is an efficiency of about 2·6 per cent., we would require, to do the work, an expenditure of 1,200 horse power each day, and since there are 293 office days, this would mean 175·8 tons which are a total waste. In addition to this, we have the knowledge that a plant, said to be economical, takes double this amount of coal under the same conditions. Our bill would now stand as follows:

Coal required at building..........		289·3 tons.
Coal wasted in mining, etc., to deliver this amount at the building.......		578·6 "
Total consumption of fuel...		867·9 "
Useful work expended in tons:		
Lighting	0·044	
Heating	85·000	85·044
Loss		782·856

It is highly probable that the average losses are double this, and in many cases treble. This is truly a state of affairs of which engineers cannot be proud. The water wheel has an efficiency of something like 90 per cent., while the best that man can do when he comes to convert the energy stored up in the coal to his own comfort is about 10 per cent.

These losses might perhaps be reduced in a variety of ways. We know, for example, that it is entirely feasible to obtain an efficiency with water wheels and generators of about 80 per cent., and we could convert the energy stored up in the electric current into heat with an efficiency of about 90 per cent., and into light with an efficiency of about 20 per cent.; or we could convert the coal at the mines into gas with an efficiency of about 80 per cent., which could be converted into energy with an efficiency of about 25 per cent.; the latter could, in turn, be converted into electricity with an efficiency of about 80 per cent., from which we could go on; or we might use gasoline, natural gas, or some other form of liquid fuel with an efficiency of about 25 per cent.

We might even pulverize the coal, and by mixing it with air produce an explosive compound, which introduced into the cylinder of an engine would give an efficiency of about 25 per cent., but all of these figures are far below those that we should attain. If, instead of steam, we had used some other form of expansive gas, we might have reached a somewhat higher efficiency still; but for all of them there is a more or less insurmountable obstacle presented by practical conditions.

We owe a great deal, beyond any doubt, to steam, but we have reached the point where we should be able to see that steam is not the panacea for all ills. Somewhere, lurking in some man's brain, there must be the rudiments of the idea that will enable us to convert effectually the stored-up energy in coal into the useful energy of the electric current. It is certain that we must come to this eventually. Take the requirements of our office building: Every man wants his office heated a little differently. No form of apparatus that can be devised that is practical will accomplish this. The electric current does it perfectly, but unfortunately it costs too much. The incandescent lamp is much the most efficient form of illumination which we at present possess for the lighting of small spaces.

Ten times more efficient is the arc lamp, but we have not yet progressed far enough on the road to subdivide it sufficiently to satisfactorily adapt it to domestic and office building lighting.

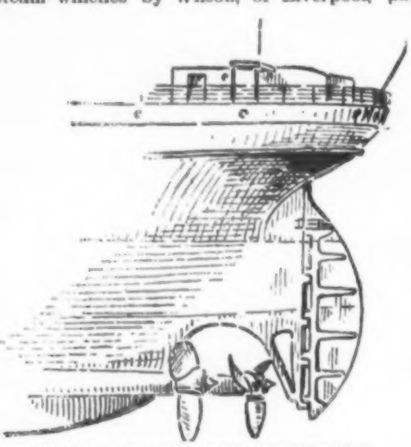
The electric elevator is now far more efficient than the hydraulic, requiring the expenditure of only about one-fourth of the number of foot-pounds and about one-tenth of the coal, but it is still inefficient in that we have no means of overcoming the waste caused by lowering people under the brakes when their weight exceeds that of the counterweight. In electricity, transmissions of over twenty miles have been made with a total efficiency of over 50 per cent., which is about ten times better than with steam, but it is much to be feared that this generation will have to be content with a comparatively wasteful form of converting energy, while fully realizing that just beyond its grasp lies one most perfect.

Do not let the fact that we are required to use the steam engine, and therefore, as its friends say, with a self-satisfied smirk, "We come back to it after all," blind us to the true condition of affairs, but rather let us hope that the day is fast approaching when it will take its true place as a scientific curiosity, illustrative of the unfortunate effects which follow from making a wrong start, the day that shall find us availing ourselves of the multitudinous forces provided on all sides by an all-wise Creator, with an efficiency equal to that already attained in the water-wheel.—*Cassier's Magazine.*

A MUSEUM now being erected at Leyden will be the largest in the world next to the British Museum. Within its walls space will be provided for eighty thousand stuffed birds.

TWIN SCREW STEAMSHIP TORR HEAD.

THIS fine vessel, just built and engined by Messrs. Harland & Wolff, for the Ulster Steamship Company, is 452 ft. long between perpendiculars, 50 ft. beam and 35 ft. 4 in. deep; about 6,000 tons gross and 3,900 tons net register, and of a dead weight carrying capacity of 8,500 tons. She has been built under special survey, and is classed A1 at Lloyd's. She has been constructed, says the *Engineer*, under the three-decked rule, considerably in excess of Lloyd's requirements; is provided with a long forecastle, very long bridge house about amidships, extending from side to side and forming a complete protection to engine and boiler casings, with long poop aft. There are six hatchways with powerful steam winches by Wilson, of Liverpool, patent

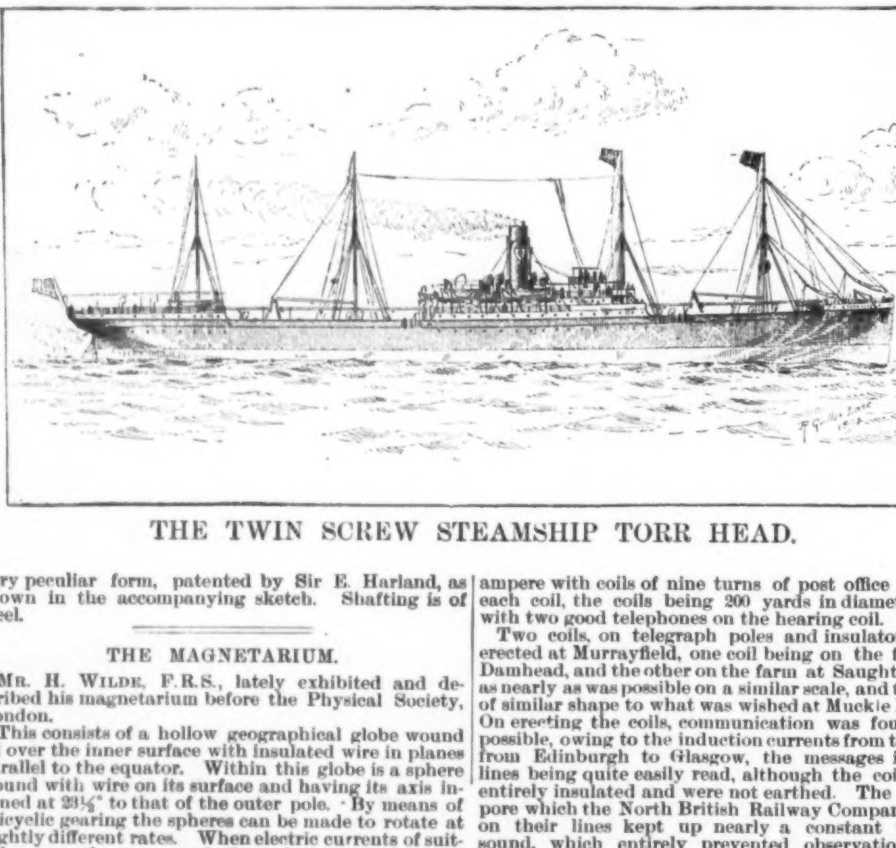


THE HANGING STERN FRAME.

steam windlass and capstan, and Pirrie & Wilson's patent spring tiller and direct steam steering gear. The Torr Head has been constructed on the cellular double bottom principle for water ballast, of which she can carry 1,400 tons, with large trimming tank aft, fitted for cargo. She has four steel pole masts, stayed on a novel plan, and stepped without any rake aft; these are for use as supports for her numerous derricks, which have full play when in port, there being no stays to interfere with their swing.

Saloon accommodation for the captain and a small number of passengers has been provided at the forward end of the bridge deck, with a teak chart house and wheel house above on the flying bridge. Engineers' and officers' quarters occupy the after end of the bridge deck. Petty officers are berthed in the forecastle and the crew in the poop. She has two heavy steel decks, and a bridge deck, covered with pine, and has a complete installation of electric light by Messrs. Holmes, Newcastle-on-Tyne.

The engines consist of two complete sets of the triple-expansion type, with all the latest improvements, indicating about 2,700 horse power at 180 lb. working pressure, steam being supplied by four steel boilers, two of them being double ended. She has a pair of screws of manganese bronze, placed extremely close together and overlapping. The stern framing is of a very peculiar form, patented by Sir E. Harland, as shown in the accompanying sketch. Shafting is of steel.



THE TWIN SCREW STEAMSHIP TORR HEAD.

THE MAGNETARIUM.

MR. H. WILDE, F.R.S., lately exhibited and described his magnetarium before the Physical Society, London.

This consists of a hollow geographical globe wound all over the inner surface with insulated wire in planes parallel to the equator. Within this globe is a sphere wound with wire on its surface and having its axis inclined at 23½° to that of the outer pole. By means of epicyclic gearing the spheres can be made to rotate at slightly different rates. When electric currents of suitable strength are passed through the two windings, the magnetic condition of the earth can be imitated, both as regards distribution at any epoch and the secular variations. A better result was obtained by putting sheet iron over the land areas, and a still closer approximation by using thin iron over the water areas. A magnetic chart and tables giving the magnetic elements at various places for different epochs were shown. The author mentioned that recent observations by the United States Survey, at Ascension Island, and by Prof. Thorpe, in Senegambia, had confirmed results obtained by the magnetarium.

The president said he had tried the apparatus and found the Siberian oval closely imitated. The secular variations, at Greenwich, were also well shown. In South America the approximation was not so good.

In reply to a question by Mr. Blakesley, Mr. Wilde said the present position of the pole of the inner sphere was 84° W., 67° N.

TELEGRAPHIC COMMUNICATION BY INDUCTION BY MEANS OF COILS.*

By Mr. CHARLES A. STEVENSON, B.Sc., F.R.S.E., M. Inst. C. E.

IN 1892 I suggested that communication could be established between ship and ship by means of coils, and as a trial of the system, on a large scale, has recently been made, with a view of establishing communication between North Unst lighthouse, situated on Muckle Flugga, and the mainland, a record of the trials may be of interest.

The induction of one spiral on another has been long known, but with a very strong battery current it has been found impossible to bridge a greater distance than 100 yards,† so that as a means of practical communication it was impossible. It has also long been known that communication could be established by means of parallel wires; and for many years this system has been under discussion, and only last month a series of elaborate experiments at Loch Ness has been made by Mr. Preece on this parallel wire system, on the most approved methods; but I trust to be able to show that the parallel wire system must give place to the method of communicating by coils.

It is evident that if two coils are placed so that their axes are coincident, their planes being parallel, or if they be placed so that their planes are in the same plane, they will be in good positions to expect electric currents sent in one to be apparent by induction in the other.

For a given diameter, and where the electrical energy is small and the number of turns small, the first position is best; but where the energy is great and the number of turns great, in fact, when it is wished to carry the induction to many times the diameter of the coils, then it will be found that it is better to let the two coils be in the same plane, as when the axes are coincident, and the coils a greater distance apart in comparison with the diameter, the difference of distance from one side of the coil, say top of primary coil to top and bottom of secondary, becomes almost a vanishing quantity; whereas, when the coils are lying on their side in the same plane, the difference of distance from back of primary to back of secondary, and from front of primary to front of secondary, does not fall off so fast, and consequently is more efficacious. Besides, it becomes impracticable to erect coils of large diameter with their planes vertical, but it is easy to lay them on their sides.

A number of experiments were made in the laboratory to discover the laws of the action of coils on each other, with the view of calculating the number of wires, the diameter of coils, the number of amperes, and the resistance of the coils that would be necessary to communicate with Muckle Flugga, and, after a careful investigation, it was evident the gap of 800 yards could, with certainty, be bridged by a current of one ampere with coils of nine turns of post office wire in each coil, the coils being 200 yards in diameter, and with two good telephones on the hearing coil.

Two coils, on telegraph poles and insulators, were erected at Murrayfield, one coil being on the farm of Damhead, and the other on the farm at Saughton, and as nearly as was possible on a similar scale, and the coils of similar shape to what was wished at Muckle Flugga. On erecting the coils, communication was found impossible, owing to the induction currents from the lines from Edinburgh to Glasgow, the messages in those lines being quite easily read, although the coils were entirely insulated and were not earthed. The phonopore which the North British Railway Company have on their lines kept up nearly a constant musical sound, which entirely prevented observations. On getting the phonopore stopped, it was found that 100 dry cells, with 1·2 ohms resistance each and 1·4 volts, gave good results, the observations being read with great ease in the secondary by means of two telephones. The cells were reduced in number down to fifteen, and messages could still easily be sent, the resistance of the primary being 24 ohms and the secondary no less than 260 ohms. If the circuit had been of good iron, with soldered joints and well earthed, the resistance should have been only 60 ohms. The induced current generated in the secondary would therefore be in the ratio of 480 to 210, or with this enormous resistance, allowing for the resistance in the two telephones in multiple, we got practically only half the current we would have got if the line had been a permanent, in place of a temporary, one.

A trial was made of the parallel wire system, and with 20 cells the sound was not heard, and with 100 cells it was heard by me as a mere scratch in comparison with the sound with the coil system with 15 cells. A trial was made with phonopore, and the coils worked with 10 cells with perfect ease, and a message was received with only 5 cells. Speech by means of Deckert's transmitter was just possible, but it is believed that if the hearing circuit had been of less resistance it would have been easy to hear.

It is difficult to understand how this system of coils, in opposition to the parallel wire system, has not been recognized as the best; for assume that, with the arrangement we had, we heard equally with 100 cells by both systems, both having the same base (200 yards), then, by simply doubling the number of turns of wire on the primary by putting on turns of thick wire, the effect would have been practically doubled, whereas by the parallel wire system there is nothing for it but to increase the battery power, which, *for practical working, becomes an impossibility.* The difficulty of the current is thus removed by using a number of turns of wire. It must always be borne in mind that the effect is the result of simply increasing the diameter, keeping current and resistance the same. The larger the diameter the better; in fact, with a given length of wire, a straight one is the best. But this is not practice. What is wanted is to get induction at a great distance from a certain given base with a small battery power, and the laboratory experiments and the trials in the field show that the way to overcome the difficulty of the current is by using a number of turns of wire. The secret of success is to apportion the resistance of primary and secondary, and the number of turns on each, to a practical battery power.

1. *Coil System.*—At 870 yards from center to center of coils, averaging each 200 yards diameter, with nine turns of wire, it was found that with a phonopore messages were sent with five dry cells, the resistance in primary being 30 ohms and the resistence of secondary 260 ohms, the current being 0·23 ampere, which, with nine turns, gives 2 ampere turns.

2. With a file as a make and break, it worked with 10 cells, giving 0·4 ampere or 3·6 ampere turns.

3. *Parallel Wire System.*—With a file as a make and break, and with parallel lines earthed, it was heard with 100 cells, giving 1·1 ampere.

The calculation of the diameter necessary to hear a given distance is simple, from the fact that the hearing distance is proportional to the square root of the diameter of one of the coils, or directly as the diameter of the two coils, so that with any given number of amperes and number of turns, to hear double the distance requires double the diameter of coils, and so on.

There is one fact which seems to have been cleared up by these trials which has even this month been a subject of discussion in London, and that is whether or not the parallel wire system is induction or conduction; and there is little room for doubt that to a large extent it is conduction, in fact that they act together; and it will depend how the ends are earthed, or, in short, what is the distance bridged in comparison to the breadth of base, which predominates. Where the wires are long in comparison with the distance bridged, conduction will be the main working factor; but when the base is small, and the distance bridged is large in comparison, induction will be the main factor, and the number of turns increases the effect.

The primary coil was insulated in the Murrayfield trials, as at Muckle Flugga it must be so, and the secondary was earthed, as is most convenient at Muckle Flugga. When the secondary was also made a complete insulated metallic circuit, with eight turns of wire, there seemed to be little difference in the result.

There is one other point to which reference must be made. Mr. Preece has been repeating the experiments brought before the Society on January 30, 1893, and he found, if rightly reported, that when the hearing wire was floating he got results, but when it was allowed to descend that no observations could be got. He attributes this to reflection from the surface of the water; this, however, is unlikely, as the reason that no sounds were then heard was that the major part of the wire lay on an equipotential line. Electro-magnetic waves enter or leave salt water practically unimpaired. On trial it was found, as stated in my paper read before this Society in January, 1893, that there was no practical difference in air or salt water to the propagation of electro-magnetic waves, the distance to which waves went, *i. e.*, the distance to which the currents could be heard, being immaterial whether the detector was sunk or in air.

It has been attempted to be shown that the coil system is not only theoretically but practically the best; and I trust that we will soon hear of the Admiralty, etc., experimenting with it, and ultimately putting it in practice. Meantime my brother has recommended the Commissioners of Northern Lighthouses to erect the coil system at Muckle Flugga, and the commissioners have approved, and I hope soon to hear of the erection of this novel system of communication at the most northern point of the British Isles, as well as on our warships, to assist in their maneuvering, by the establishment of instantaneous communication unaffected by wind or weather.

The application of the coil system to communication with light vessels is obvious, viz., to moor the vessel in the ordinary way, and lay out from the shore a cable, and circle the area over which the lightship moorings will permit her to travel, by a coil of the cable the required diameter, which will be twice the length of her chain cable. On board the vessel there will be another coil of a number of turns of thick wire.

Ten cells on the lightship and ten on the shore will be sufficient for the installation. The system erected at Kentish Knock and other light vessels is expensive in moorings, and is liable to derangement and requires special mooring, whereas by the coil system there can

* Paper read before the Royal Society of Edinburgh.

† *Journal* of the Society of Arts, vol. xlii, page 274.

be no derangement, and the vessel can be moored in the ordinary way. A call arrangement and telephones complete the installation.

A HISTORY OF THE TELEPHONE.*

By W. CLYDE JONES.

IT was in 1819 that Oersted, a professor in the University of Copenhagen, while lecturing to his class, discovered that a magnetic needle, when held in the vicinity of a wire traversed by an electric current, was caused to assume a position at right angles to the axis of the wire. This experiment, though simple of performance, was a revelation to the scientific world, and confirmed the long-standing suspicion that electricity and magnetism were, in some mysterious manner, related. This was the spark that inflamed the minds of scientific men and led to the unraveling of the apparent mysteries of electro-magnetic action and the founding of the laws of electro-magnetism, to which we are in such a great measure indebted for the industrial development of the electrical arts.

Oersted had informed the world that there was a relation between electricity and magnetism, but it remained for Sturgeon, in 1825, to point out that there was not only a relation, but that electricity was even convertible into magnetism. He had encircled a bar of soft iron with a helix of wire and noted that upon the passage of an electric current through the helix the soft iron bar assumed the properties of a magnet. Here was the germ that was afterward developed into the telegraph and the telephone.

With the electro-magnet the minds of men naturally turned to the transmission of intelligence to a distance, and in the years immediately following Sturgeon's experiment we find the greatest scientific minds busily engaged with the problem. Neither the laws of the electro-magnet nor the laws governing the passage of a current along a wire, since so admirably expressed by Ohm, were at this time known, and the rapid falling away of the force of the current with increased distance led to the belief that an electro-magnetic telegraph would never be possible. Indeed, in 1829, Professor Barlow, of England, perhaps the foremost scientist of his day, after making an exhaustive study of the problem, published a demonstration, considered at the time conclusive, showing that it would be absolutely impossible to transmit intelligence to a distance by means of the electro-magnet.

But soon the dormant hope was again aroused by the publication of the researches of Joseph Henry, who had so thoroughly investigated the laws of the electro-magnet that no discoveries except of minor importance have resulted from later investigation; in fact, the electro-magnet as Henry knew it in 1830 is the electro-magnet as we know it to-day.

Ever since Sturgeon had converted electricity into magnetism the question ever uppermost in scientific minds was whether magnetism might not in turn be converted into electricity. In 1831 Henry and Faraday discovered that magnetism was, in fact, convertible into electricity, and was effected by varying the magnetic field threading a looped conductor. By this discovery, which has rendered illustrious the names of two great men, the world acquired information concerning the laws of electro-magnetism and the mutual convertibility of the two mysterious forces that immediately removed electrical science from the domain of the purely theoretical and experimental and gave it a place in the industrial world.

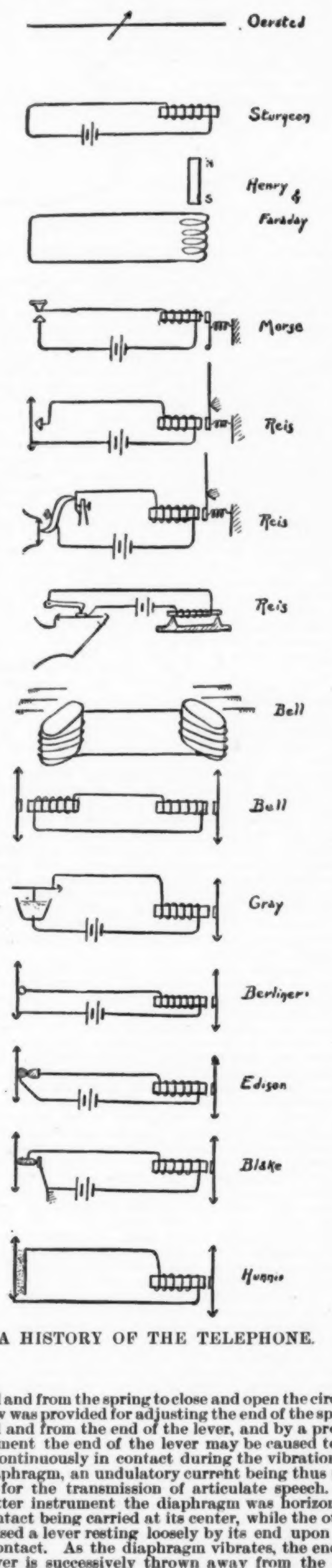
The time was now ripe for the development of the electric telegraph, and in the early 30's Samuel F. B. Morse had conceived the electric telegraph, which, toward the end of the decade, assumed practical form. With Sturgeon's electro-magnet placed at the distant end of the line, he closed an electric circuit by means of a key, thus causing the electro-magnet to attract its armature and convey to the operator at the distant end of the line the conventional signal.

Naturally, the operation of the Morse telegraph suggested the possibility of transmitting the voice itself to a distance, and, indeed, as early as 1854 we find Charles Boursel publishing to the world the possibility of speech transmission in words that have since become historic. He said: "I have asked myself if the spoken word itself could not be transmitted by electricity; in a word, if what was spoken in Vienna may not be heard in Paris. . . . Suppose that a man speaks near a movable disk sufficiently flexible to lose none of the vibrations of the voice; that this disk alternately makes and breaks the connection with a battery; you may have at a distance another disk which will simultaneously execute the same vibrations"

Boursel erroneously supposed that the voice could be transmitted by the opening and closing of the circuit, and thus outlined a path of research which science traveled for twenty years, until Bell, by his theory of electric undulations, removed it from the deeply worn rut. In 1861 Philip Reis, of Frankfort, Germany, apparently following the instruction of Boursel, constructed the first telephone, which comprised as a transmitter a diaphragm, adapted in its vibration to open and close an electric circuit. At the receiving station was placed an electro-magnet, which, by the successive current impulses sent over the line by the transmitter, caused the magnet to alternately attract and release its armature, to which was secured a thin plate, which in the vibration of the armature was moved back and forth, thus beating the air and setting in motion the air particles that conveyed to the ear the sense of sound.

By comparing the telephone of Reis with the telegraph of Morse, it will be observed that the transmitting instruments differ only in that Morse used a key actuated by the hand for opening and closing the circuit, while Reis provided a diaphragm which, for the sake of the analogy, we may consider a key adapted to be actuated not by the hand but by the vocal organs. Again, the only essential difference between the receiving instruments was that Reis had applied to the armature of the Morse instrument a thin plate for the purpose of setting the air particles in motion.

Reis, by opening and closing the circuit, was unable to transmit the complex current undulations upon which we know the transmission of articulate speech to depend, and was only able to transmit simple musical sounds. It has been contended by some that Reis actually transmitted articulate speech by means of his apparatus and understood the requisite of speech transmission, and, in fact, that speech has actually been transmitted by the Reis apparatus by causing the contacts of the transmitter to remain continuously in contact; but that Reis himself did not understand the necessity of an undulatory current and did not transmit speech may be inferred from the fact that in his later apparatus, which was by him considered an improvement upon the former, the construction was such that it is impossible to cause the contacts to remain continuously in contact. In the former instrument a pivoted lever was provided, one end bearing against the diaphragm and the other end against the end of a spring the circuit being from the lever to the spring. As the diaphragm is vibrated, the end of the lever is moved



A HISTORY OF THE TELEPHONE.

toward and from the spring to close and open the circuit. A screw was provided for adjusting the end of the spring toward and from the end of the lever, and by a proper adjustment the end of the lever may be caused to remain continuously in contact during the vibration of the diaphragm, an undulatory current being thus produced for the transmission of articulate speech. In the latter instrument the diaphragm was horizontal, one contact being carried at its center, while the other comprised a lever resting loosely by its end upon the first contact. As the diaphragm vibrates, the end of the lever is successively thrown away from the diaphragm to open and close the circuit. By this construction it will be observed that the contacts cannot be caused to remain continuously in contact.

It will be observed that there is a remarkable resemblance between the receiver of Reis and the magneto telephone of Bell, the difference being that Bell secures the thin plate by its edges and provides the armature at its center, while Reis mounts the plate upon a horizontal axis and places the armature upon one end. In both the function of the plates is to beat the air; in both the function of the magnet and armature is to set the plate in motion.

We see, therefore, that Reis actually had a receiver capable of reproducing articulate sounds, had he but understood the necessities of the transmitter, and that by adjusting his transmitter, so that the contacts would remain continuously in contact, he would have had an articulating transmitter. Further than this, had he connected two of his receivers together and used one as a transmitter, speech might have been transmitted. With apparatus of such possibilities, it does, indeed, seem remarkable that the mere oversight of not having turned a screw a fractional rotation on its axis, or of not having connected two particular binding posts by a wire, should have shifted the honor of having first transmitted articulate speech from the shoulders of Reis to those of men living half a generation later.

The apparatus of Reis, as Reis used it, was incapable of transmitting articulate speech, since the only effect of each vibration of the diaphragm was to close the circuit of a battery and send a current impulse over the line. These current impulses being always of the same strength, the vibrating plate of the receiver always produced tones of a given loudness, but as the rate of vibration of the transmitter varied, the rate of vibration of the receiver plate correspondingly varied, the apparatus being thus capable of reproducing the pitch of the sounds. But in complex sounds, and particularly sounds comprising articulate speech, the air particles do not perform a simple to-and-fro movement in constituting the sound, but perform the cycle with more or less complexity, now advancing rapidly, now slower, perhaps receding slightly, and then advancing to complete the stroke, and it is evident that any transmitter that fails to register all of these variations will fail to transmit articulate speech. Since the transmitting diaphragm of the Reis telephone merely registered the completion of the stroke and not the intermediate movements, it was, of course, incapable of transmitting articulate speech.

In the early seventies, Alexander Graham Bell was working upon a harmonic telegraph which, in its essential features, comprises a permanent magnet, opposite the pole of which were located a number of reeds each adapted to vibrate at a different rate. Encircling the magnet was a coil of wire connected with the coil of a similar instrument at a distance. When one of the reeds was set in vibration it executed a definite number of vibrations, the number being peculiar to the reed, and the successive approach of its end to the end of the magnet varied the strength of the magnet, thus inducing in the coil a current which, traversing the coil at the receiving station, varied the strength of the magnet which it encircled to cause the successive attraction of a reed having the same characteristic vibration.

None of the reeds at the receiving station thus vibrate except those whose correspondents at the transmitter vibrate, and if a number of the reeds at the transmitting station are caused to vibrate, the corresponding reeds at the receiving station are set in vibration.

Now, since complex sounds may be resolved into a number of superimposed simple sounds, Bell concluded that if the reeds be mounted flexibly enough to vibrate under the influence of sound waves, and are sufficient in number, a person in speaking against the reeds would set such reeds, the vibration of which when compounded produce the sound, into vibration, thus causing the corresponding reeds at the receiver to vibrate and reproduce the sound. From this conception of the production of all the simple tones of which the complex tone is composed, Bell, taking a lesson from the human ear, advanced to the conception of a diaphragm which should have not a characteristic vibration to respond to a particular sound, but which should respond to all sounds, and the development of this idea led to the production of the magnetic telephone.

Elisha Gray was at this time also working upon a harmonic telegraph, and independently conceived the requisite of speech transmission. His receiver embodied the principle of Bell's telephone, but for a transmitter he provided means for producing changes in the resistance of an electric circuit by the variable immersion in a body of mercury of a needle carried upon the diaphragm, the needle and the mercury being included in the circuit.

It soon became evident that the electro-dynamic or resistance varying telephone of Gray was the best for transmitting the sounds, and the improvements of Berliner, Edison and Blake soon followed. After an interference in the Patent Office, it was decided that Berliner was the first to conceive the use of two electrodes continuously in contact for varying the resistance; that Edison was the first to provide electrodes of carbon, while Blake first mounted the electrodes upon springs in a manner to prevent the breaking of the circuit, and employed platinum as one electrode.

The variations of current produced by solid electrodes is limited, and the transmitter has been improved by Hunning by using granular carbon between a stationary plate and the vibrating diaphragm, a greater variation of resistance for a given movement of the diaphragm being thus secured.

The Hunning transmitter, with improvements for preventing the caking of the granular material, marks the highest stage of development of the telephone transmitter.

Thus we see that the development of the telephone has been a gradual one, and has followed a logical course, and is perhaps one of the most striking examples of the fact that great inventions do not spontaneously emanate from the mind of one great man far in advance of his age, but that each but adds his mite to the amassed knowledge of society, the process continuing until some one happily supplies that last step which, added to what has been done before, carries the undertaking within the pale of success, the last step being perhaps of no greater intrinsic merit than the others, but by virtue of its position, like the keystone that completes the arch, it becomes of the greatest relative importance. The steps when considered in

* Read before the Chicago Electrical Association, January 23, 1894.

the light of retrospect often seem small, indeed, yet they were all necessary to accomplish the completed journey. Thus we see that Morse did little more than provide a key for Sturgeon's electro-magnet. Reis did but little more than substitute for the manual key of Morse one more sensitively constructed to be operated by the vocal organs, and, instead of pounding a metal stop with the armature of the electro-magnet, pounded the air. Bell did but little more than mount the plate of Reis as a diaphragm and conceive the idea of using it as a transmitting instrument to produce the all-essential undulatory current, and in fact all of the variable contact transmitters are but little more than the Reis transmitter properly adjusted. But while we, standing at a distance, are thus able to verify the words, well said, that "science moves but slowly, slowly, creeping on from point to point," we must not forget that the act is more difficult in the performance than in the after contemplation, and that all of those to whom we are indebted for the perfection of the telephone, from Oersted to Hunning, merit our praise, for each has performed an indispensable part.

THE ORIGIN OF ANTHRACITE.

THE main difference between anthracite and bituminous coal is that the former is devoid of volatile matter. Heretofore the theory generally accepted to account for this difference was that presented a half century ago by Prof. Rogers, while conducting the first geological survey of Pennsylvania. Observing that the anthracite beds lay in the eastern part of the State, in close proximity to the Archean axis of elevation, he surmised that these coal beds had, so to speak, been "cooked" upon the elevation of the Appalachian chain; that is, he supposed that the heat and pressure accompanying the Appalachian elevation, acting most vigorously near the axis, had distilled and removed the volatile matter of the coal beds nearest it.

To adjust the theory to increasing facts, Prof. Lesley added the supposition that the heat involved in this theory was brought up by conduction when the superincumbent layers of rock were extremely thick, which have since been mainly removed by the erosive agencies which have been active over the region for millions of years.

The inadequacy of these theories has led Prof. J. J. Stevenson, of the University of New York, to propound another and simpler theory, which was ably defended by him at the recent meeting of the Geological Society of America.

He would account for the lack of volatile matter in anthracite coal by the simple fact that it had been longer exposed to that kind of decay which takes place in vegetable matter when immersed in water, a decay which consists chiefly in the loss of the hydrocarbons, which constitute the volatile elements in bituminous coal. On this supposition the anthracite beds are those which were formed earliest in the swamps and lagoons of the carboniferous period and remained longest devoid of the covering of sedimentary deposits which subsequently preserved them from further change.

This theory is confirmed by the fact that there is no such strict relation of the anthracite beds to the Appalachian axis of elevation as Prof. Rogers had supposed, and by many other considerations which Prof. Stevenson is about to publish. This simple cause seems adequate to account for all the phenomena, and probably solves one of the long-standing mysteries of geological science.

ISOPERIMETRICAL PROBLEMS.*

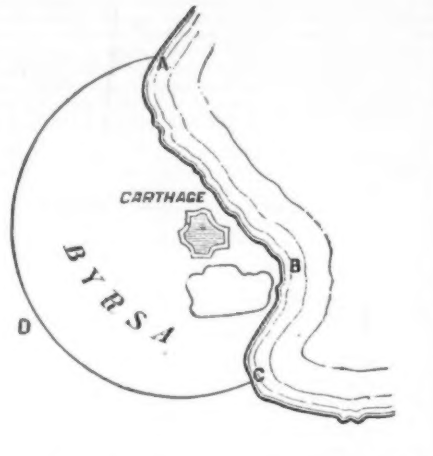
By LORD KELVIN.

Dido, B. C. 800 or 900.
Horatius Cocles, B. C. 508.
Pappus, Book v. A. D. 390.
John Bernoulli, A. D. 1700.
Euler, A. D. 1744.
Maupertuis (Least Action), b. 1698, d. 1759.
Lagrange (Calculus of Variations), 1759.
Hamilton (Actional Equations of Dynamics), 1834.
Liouville, 1840 to 1860.

THE first isoperimetrical problem known in history was practically solved by Dido, a clever Phenician princess, who left her Tyrian home and emigrated to North Africa, with all her property and a large retinue, because her brother Pygmalion murdered her rich uncle and husband Acerbas, and plotted to defraud her of the money which he left. On landing in a bay about the middle of the north coast of Africa she obtained a grant from Hiarbas, the native chief of the district, of as much land as she could inclose with an ox hide. She cut the ox hide into an exceedingly long strip, and succeeded in inclosing between it and the sea a very valuable territory† on which she built Carthage.

The next isoperimetrical problem on record was three or four hundred years later, when Horatius Cocles, after saving his country by defending the bridge until it was destroyed by the Romans behind him, saved his own life and got back into Rome by swimming the Tiber under the broken bridge, and was rewarded by his grateful countrymen with a grant of as much land as he could plow round in a day.

In Dido's problem the greatest value of land was to be inclosed by a line of given length. If the land is all of equal value, the general solution of the problem shows that her line of ox hide should be laid down in a circle. It shows also that if the sea is to be part of the boundary, starting, let us say, southward from any *given* point A of the coast, the inland bounding line must at its far end cut the coast line perpendicularly. Here, then, to complete our solution, we have a very curious and interesting, but not at all easy, geometrical question to answer: What must be the radius of a circular arc A D C, of given length, and in what direction must it leave the point A, in order that it may cut a given curve A B C perpendicularly at some unknown point, C? I do not believe Dido could have passed an examination on the subject, but no doubt she gave a very good practical solution, and better than she would have found if she had just mathematics enough to make her fancy the boundary ought to be a circle. No doubt she gave it different curvature in different parts to bring in as much as possible of the more valuable parts of the land offered to her, even though difference of curvature in different parts would cause the total area



inclosed to be less than it would be with a circular boundary of the same length.

The Roman reward to Horatius Cocles brings in quite a new idea, now well known in the general subject of isoperimetrics; the greater or less speed attainable according to the nature of the country through which the line traveled over passes. If it had been equally easy to plow the furrow in all parts of the area offered for inclosure, and if the value of the land per acre was equal throughout, Cocles would certainly have plowed as nearly in a circle as he could, and would only have deviated from a single circular path if he found that he had misjudged its proper curvature. Thus, he might find that he had begun on too large a circle, and, in order to get back to the starting point and complete the inclosure before nightfall, he must deviate from it on the concave side; or he would deviate from it on the other side if he found that he had begun on too small a circle, and that he had still time to spare for a wider sweep. But, in reality, he must also have considered the character of the ground he had to plow through, which cannot but have been very unequal in different parts, and he would naturally vary the curvature of his path to avoid places where his plowing must be very slow, and to choose those where it would be most rapid.

He must also have had, as Dido had, to consider the different value of the land in different parts, and thus he had a very complex problem to practically solve. He had to be guided both by the value of the land to be inclosed and the speed at which he could plow according to the path chosen; and he had a very brain-trying task to judge what line he must follow to get the largest value of land inclosed before night.

These two very ancient stories, whether severe critics will call them mythical or allow them to be historic, are nevertheless full of scientific interest. Each of them expresses a perfectly definite case of the great isoperimetrical problem to which the whole of dynamics is reduced by the modern mathematical methods of Euler, Lagrange, Hamilton and Liouville (Liouville's Journal, 1840-1850). In Dido's and Horatius Cocles' problems, we find perfect illustrations of all the fundamental principles and details of the generalized treatment of dynamics which we have learned from these great mathematicians of the eighteenth and nineteenth centuries.

Nine hundred years after the time of Horatius Cocles we find, in the fifth book of the collected Mathematical and Physical Papers of Pappus, of Alexandria, still another idea belonging to isoperimetrics—the economy of valuable material used for building a wall; which, however, is virtually the same as the time per yard of furrow in Cocles' plowing. In this new case the economist is not a clever princess, nor a patriot soldier, but a humble bee who is praised in the introduction to the book not only for his admirable obedience to the authorities of his republic, for the neat and tidy manner in which he collects honey, and for his prudent thoughtfulness in arranging for its storage and preservation for future use, but also for his knowledge of the geometrical truth that a "hexagon can inclose more honey than a square or a triangle with equal quantities of building material in the walls," and for his choosing on this account the hexagonal form for his cells. Pappus, concluding his introduction with the remark that bees only know as much of geometry as is practically useful to them, proceeds to apply what he calls his own superior human intelligence to investigation of useless knowledge, and gives results in his Book V. which consists of fifty-five theorems and fifty-seven propositions on the areas of various plane figures having equal circumferences. In this book, written originally in Greek, we find (Theorem IX., Proposition X.) the expression "isoperimetrical figures," which is, so far as I know, the first use of the adjective "isoperimetrical" in geometry; and we may, I believe, justly regard Pappus as the originator, for mathematics, of *isoperimetrical problems*, the designation technically given in the nineteenth century* to that large province of mathematical and engineering science in which different figures having equal circumferences, or different paths between two given points, or between some two points on two given curves, or on one given curve, are compared in connection with definite questions of greatest efficiency and smallest cost.

In the modern engineering of railways, an isoperimetrical problem of continual recurrence is the laying out of a line between two towns along which a railway may be made at the smallest prime cost. If this were to be done irrespectively of all other considerations, the requisite datum for its solution would be simply the cost per yard of making the railway in any part of the country between the two towns. Practically the solution would be found in the engineers' drawing office by laying down two or three trial lines to begin with, and calculating the cost of each, and choosing the one of which the cost is least. In practice various other considerations than very slight differences in the cost of construction will decide the ultimate choice of the exact line to be taken; but if the problem were put before a capable engineer to find very exactly the line of minimum total cost, with an absolutely definite statement of the cost per yard in every part of the country, he or his draughtsmen would know perfectly how to find the solution. Having found something near the true line by a few rough trials, they would try small deviations from the rough approximation, and calculate differences of cost for different lines differing very little from one another. From their drawings and calculations they would judge by eye which way they must deviate from the best line already found to find one still better. At last they would find two lines for which their calculation shows no difference of cost. Either of these might be chosen; or, according to judgment, a line midway between them, or somewhere between them, or even not between them, but near to one of them, might be chosen, as the best approximation to the exact solution of the mathematical problem which they care to take the labor of trying for. But it is clear that if the price per yard of the line were accurately given (however determined or assumed), there would be an absolutely definite solution of the problem, and we can easily understand that the skill available in a good engineer's drawing office would suffice to find the solution with any degree of accuracy that might be prescribed; the minuter the accuracy to be attained, the greater the labor, of course. You must not imagine that I suggest, as a thing of practical engineering, the attainment of minute accuracy in the solution of a problem thus arbitrarily proposed; but it is interesting to know that there is no limit to the accuracy to which this ideal problem may be worked out by the methods which are actually used every day by engineers in their calculations and drawings.

The modern method of the "calculus of variations," brought into the perfect and beautiful analytical form in which we now have it by Lagrange, gives for this particular problem a theorem which would be very valuable to the draughtsman if he were required to produce an exceedingly accurate drawing of the required curve. The curvature of the curve at any point is convex toward the side on which the price per unit length of line is less, and is numerically equal to the rate per mile perpendicular to the line at which the Neperian logarithm of the price per unit length of the line varies. This statement would give the radius of curvature in fraction of a mile. If we wish to have it in yards, we must take the rate per yard at which the Neperian logarithm of the price per unit length of the line varies. I commend the Neperian logarithm of price in pounds, shillings and pence to our honorary secretary, to whom no doubt it will present a perfectly clear idea; but less powerful men would prefer to reckon the price in pence, or in pounds and decimals of a pound. In every possible case of its subject the "calculus of variations" gives a theorem of curvature less simple in all other cases than in that very simple case of the railway line of minimum first cost, but always interpretable and intelligible according to the same principles.

Thus in Dido's problem we find by the calculus of variations that the curvature of the inclosing line varies in simple proportion to the value of the land at the places through which it passes; and the curvature at any one place is determined by the condition that the whole length of the ox hide just completes the inclosure.

The problem of Horatius Cocles combines the railway problem with that of Dido. In it the curvature of the boundary is the sum of two parts; one, as in the railway, equal to the rate of variation perpendicular to the line, of the Neperian logarithm of the cost in time per yard of the furrow (instead of cost in money per yard of the railway); the other varying proportionally to the value of the land as in Dido's problem, but now divided by the cost per yard of the line, which is constant in Dido's case. The first of these parts, added to the ratio of the money value per square yard of the land to the money cost per lineal yard of the boundary (a wall suppose), is the curvature of the boundary when the problem is simply to make the most you can of a grant of as much land as you please to take provided you build a proper and sufficient stone wall round it at your own expense. This problem, unless wall building is so costly that no part of the offered land will pay for the wall round it, has clearly a determinate finite solution if the offered land is an oasis surrounded by valueless desert. It has also a determinate finite solution even though the land be nowhere valueless, if the wall is sufficiently more and more expensive at greater and greater distances from some place where there are quarries, or habitations for the builders.

The simplified case of this problem, in which all equal areas of the land are equally valuable, is identical with the old well-known Cambridge dynamical plane problem of finding the motion of a particle relatively to a line of reference revolving uniformly in a plane; to which belongs that considerable part of the "Lunar Theory" in which any possible motion of the moon is calculated on the supposition that the center of gravity of the earth and moon moves uniformly in a circle round the sun, and that the motions of the earth and moon are exactly in this plane. The rule for curvature which I have given you expresses in words the essence of the calculation, and suggests a graphic method for finding solutions by which not uninteresting approximations* to the cusped and looped orbits of G. F. Hill† and Poincaré‡ can be obtained without disproportionately great labor.

* A lecture delivered at the Royal Institution, May 12, 1893, by Lord Kelvin, Pres. R.S.—*Nature.*

† Called Byrsa, from βύρσα, the hide of a bull. (Smith's "Dictionary of Greek and Roman Biography and Mythology," article "Dido.")

* Example, Woodhouse's "Isoperimetrical Problems," Cambridge, 1810.

* Kelvin "On Graphic Solution of Dynamical Problems." *Phil. Mag.*, 1892 (second half year).

† Hill, "Researches in the Lunar Theory," Part 3. "National Academy of Sciences," 1887.

‡ "Méthodes Nouvelles de la Mecanique Celeste," p. 109 (1892).

In the dynamical problem, the angular velocity of the revolving line of reference is numerically equal to half the value of the land per square yard; and the relative velocity of the moving particle is numerically equal to the cost of the wall per lineal yard in the land question.

But now as to the proper theorem of curvature for each case: both Dido and Horatius Cocles no doubt felt it instinctively and were guided by it, though they could not put it into words, still less prove it by the "calculus of variations." It was useless knowledge to the bees, and, therefore, they did not know it; because they had only to do with straight lines. But as you are not bees I advise you all, even though you have no interest in acquiring as much property as you can inclose by a wall of given length, to try Dido's problem for yourselves, simplifying it, however, by doing away with the rugged coast line for part of your boundary, and completing the inclosure by the wall itself. Take forty inches of thin soft black thread with its ends knotted together and let it represent the wall; lay it down on a large sheet of white paper and try to inclose the greatest area with it you can. You will feel that you must stretch it in a circle to do this, and then, perhaps, you will like to read Pappus (Liber V., Theorema II., Propositio II.) to find mathematical demonstration that you have judged rightly for the case of all equal areas of the inclosed land equally valuable. Next try a case in which the land is of different value in different parts.

Take a square foot of white paper and divide it into 144 square inches to represent square miles, your forty inches of endless thread representing a forty mile wall to inclose the area you are to acquire. Write on each square the value of that particular square mile of land, and place your endless thread upon the paper, stretched round a large number of smooth pins stuck through the paper into a drawing board below it, so as to inclose as much value as you can, judging first roughly by eye and then correcting according to the sum of the values of complete squares and proportional values of parts of squares inclosed by it. In a very short time you will find with practical accuracy the proper shape of the wall to inclose the greatest value of the land that can be inclosed by forty miles of wall. When you have done this you will understand exactly the subject of the calculus of variations, and those of you who are mathematical students may be inclined to read Lagrange, Woodhouse, and other modern writers on the subject.

The problem of Horatius Cocles, when not only the different values of the land in different places but also the different speed of the plow according to the nature of the ground through which the furrow is cut are taken into consideration, though more complex and difficult, is still quite practicable by the ordinary graphic method of trial and error. The analytical method of the calculus of variations, of which I have told you the result, gives simply the proper curvature for the furrow in any particular direction through any particular place. It gives this and it cannot give anything but this, for any plane isoperimetrical problem whatever, or for any isoperimetrical problem on a given curved surface of any kind.

Beautiful, simple, and clear as isoperimetrics is in geometry, its greatest interest, to my mind, is in its dynamical applications. The great theorem of least action, somewhat mystically and vaguely propounded by Maupertuis, was magnificently developed by Lagrange and Hamilton, and by them demonstrated to be not only true throughout the whole material world, but also a sufficient foundation for the whole of dynamical science.

It would require nearly another hour if I were to explain to you fully this grand generalization for any number of bodies moving freely, such as the planets and satellites of the solar system, or any number of bodies connected by cords, links, or mutual pressures between hard surfaces, as in a spinning wheel, or lathe and treadle, or a steam engine, or a crane, or a machine of any kind; but even if it were convenient to you to remain here an hour longer I fear that two hours of pure mathematics and dynamics might be too fatiguing. I must, therefore, perforce limit myself to the two dimensional, but otherwise wholly comprehensive, problems of Dido and Horatius Cocles. Going back to the simpler included case of the railway of minimum cost between two towns, the dynamical analogue is this: For price per unit length of the line substitute the velocity of a point moving in a plane under the influence of a given conservative system of forces, that is to say, such a system that when material particles not mutually influencing one another are projected from one and the same point in different directions, but with equal velocities, the subsequent velocity of each is calculable from its position at any instant, and all have equal velocities in traveling through the same place whatever may be their directions. The theorem of curvature, of which I told you in connection with the railway engineering problem, is now simply the well-known elementary law of relation between curvature and centrifugal force of the motion of a particle.

The motion of a particle in a plane is, as Liouville has proved, a case to which every possible problem of dynamics involving just two freedoms to move can be reduced. But to bring you to see clearly its relation to isoperimetrics, I must tell you of another admirable theorem of Liouville's, reducing to a still simpler case the most general dynamics of two freedoms motion. Though not all mathematical experts, I am sure you can all perfectly understand the simplicity of the problem of drawing the shortest line on any given convex surface, such as the surface of this block of wood (shaped to illustrate Newton's dynamical theory of the elliptic motion of a planet round the sun) which you see on the table before you.

I solve the problem practically by stretching a thin cord between the two points, and pressing it a little this way or that way with my fingers till I see and feel that it lies along the shortest distance between them. And now, when I tell you that Liouville has reduced to this splendidly simple problem of drawing a shortest line (geodetic line it is called) on any given curved surface every conceivable problem of dynamics involving only two freedoms to move, I am sure you will understand sufficiently to admire the great beauty of this theorem.

The doctrine of isoperimetrical problems in its relation to dynamics is very valuable in helping to theoretical investigation of an exceedingly important subject for astronomy and physics—the stability of motion, regarding which, however, I can only this evening venture to show you some experimental illustrations.

The lecture was concluded with experiments illustrating:

1. Rigid bodies (teetotums, boys' tops, ovals, oblates, etc.) placed on a horizontal plane, and caused to spin round on a vertical axis, and found to be thus rendered stable or unstable according as the equilibrium without spinning is unstable or stable.

2. The stability or instability of a simple pendulum, whose point of support is caused to vibrate up and down in a vertical line, investigated mathematically by Lord Rayleigh.

3. The crispations of a liquid supported on a vibrating plate, investigated experimentally by Faraday; and the instability of a liquid in a glass jar, vibrating up and down in a vertical line, demonstrated mathematically by Lord Rayleigh.

4. The instability of water in a prolate hollow vessel, and its stability in an oblate hollow vessel, each caused to rotate rapidly round its axis of figure,* which were announced to Section A of the British Association at its Glasgow meeting in 1876 as results of an investigation not then published, and which has not been published up to the present time.

* Nature, 1877, vol. xv., p. 297, "On the Precessional Motion of a Liquid."

BASIC SULPHATE OF ALUMINA.

ACCORDING to a paper read by Mr. W. C. Ferguson, before the American Chemical Society, many samples of commercial sulphate of alumina contain more or less of an excess of alumina over that required to form the normal sulphate ($Al_2(SO_4)_3$), the amount varying from a trace to 2½ per cent. and occasionally even more.

The following composition is of frequent occurrence: Total soluble alumina = 17·00 per cent.; soluble alumina calculated from sulphuric anhydride (SO_3) to form $Al_2(SO_4)_3$ = 15·2 per cent., leaving 1·8 per cent. of alumina in excess of that required to form the normal sulphate.

It is concerning the probable chemical constitution of this alumina in excess of that required to form the normal sulphate, together with its behavior toward resin soap in the manufacture of paper, that this brief article is written.

As is well known, in sizing paper, sulphate of alumina is made to react on resin soap (made by saturating soda ash with resin), thus precipitating an insoluble alumina soap, a resinate of alumina in the fiber of the paper.

In many paper works the per cent. of normal sulphate $Al_2(SO_4)_3$ determines the strength of the material bought and, other things being favorable, that is preferred which contains the highest per cent. of $Al_2(SO_4)_3$.

A number of reports from paper mills are about as follows:

$$\begin{cases} \text{Combined } Al_2O_3 = 15{\cdot}20 = Al_2(SO_4)_3 = 50{\cdot}96 \\ \text{Free } Al_2O_3 = 1{\cdot}80, \text{ or} \end{cases}$$

$$\begin{cases} Al_2(SO_4)_3 = 50{\cdot}96 \\ Al_2O_3 = 1{\cdot}80 \end{cases}$$

In such reports the "combined" Al_2O_3 and also the $Al_2(SO_4)_3$ are calculated from the SO_3 present and the soulubie so-called "free" Al_2O_3 is ignored as being of no value for sizing purposes. This idea, that has so little, if anything, to support it, is discussed below.

A solution of normal sulphate of alumina behaves very much like an acid; it combines with bases, evolves hydrogen with metals, and is acid to litmus paper. We should, therefore, expect SO_3 to combine with more alumina than is represented by the normal sulphate, and it might be added that as weak bases have the characteristic of forming basic salts, we should for this reason also anticipate the formation of basic sulphates of alumina. These basic sulphates can readily be formed in the laboratory from the normal sulphate.

1. By dissolving alumina in the normal sulphate.

2. By action of caustic alkalies on a solution of the normal sulphate. $Al_2(SO_4)_3 + Na_2O = Al_2O_3(SO_3)_2 + Na_2SO_4$.

For example: A solution of normal sulphate of alumina containing seven per cent. of alumina can be made two per cent. basic by adding caustic soda slowly to a hot solution until a precipitate forms that does not dissolve even on long boiling. This is equivalent in a seventeen per cent. material to having 4·86 per cent. in excess of that required to form $Al_2(SO_4)_3$.

3. By action of a metal, $Al_2(SO_4)_3 + Zn + H_2O = ZnSO_4 + Al_2O_3(SO_3)_2 + H_2$.

These equations are only intended to illustrate the probable types of reaction; it is not assumed that just such compounds are formed.

The following standard works treat of a number of basic sulphates of alumina that are soluble in water: Watts' "Dictionary of Chemistry," Roscoe and Schorlemmer's "Chemistry," Mendelejeff's "Principles of Chemistry." A careful search through the literature fails to reveal any reference to "free" alumina existing in a solution of normal sulphate.

The term "free" implies the reverse of combined, and from the considerations given above it is not deemed best to call the alumina contents in excess of that required to form normal sulphate "free," with every condition favoring combination. Such alumina is undoubtedly combined as basic sulphate, and being in solution there is every reason to believe that it would form a resinate of alumina with resin soap as readily as the normal sulphate, and some ground for the assumption that it might be even more available, because it is probably held in weaker combination, and so would be more readily decomposed and precipitated as size; and if this were true, such basic alumina would be more valuable than the normal, because more would be precipitated by a given weight of resin soap. With these considerations in mind the following investigations were carried out in the laboratory. In order to observe the action of resin soap on a solution in which the alumina approaches nearest to the free state, some aluminate of soda was prepared by dissolving alumina in caustic soda. In this solution alumina is so feebly held in combination that the weakest acids, such as carbonic, will replace it. The solution is basic, and alkaline to test paper.

Resin soap immediately precipitates a voluminous precipitate of resinate of alumina. Even upon the addition of a drop or two of resin soap the precipitate begins to form.

A comparison of a neutral sulphate containing 17 per cent. soluble alumina and of a basic sulphate containing 17 per cent. total soluble alumina, 15 per cent. being normal and 2 per cent. being basic (the so-called "free"), were each treated with an equal amount of resin soap in such quantity that but a portion of the alumina was precipitated. The solutions were filtered and precipitates washed with equal amounts of water and ignited. It was found that under such conditions

4·40 grammes were precipitated from the neutral solution,

6·98 grammes were precipitated from the basic solution.

These results are what theory would anticipate.

A brief summary of the case is this: It would seem that there is no "free" soluble alumina in the basic sulphate of alumina of commerce; such alumina is in direct combination as basic sulphate, and being more feebly held in combination than alumina combined as normal sulphate, more readily forms size with resin soap and is therefore more economical, less resin soap being required for a given weight of sulphate. It directly follows from this that in any sulphate of alumina the $Al_2(SO_4)_3$ should be calculated from the total soluble alumina and *not* from that combined as normal sulphate alone, as in the latter case the most valuable alumina content is ignored as being useless. The following example will serve to illustrate the difference in value based on the two types of analyses: In a sulphate of alumina analyzing

Total soluble alumina....	17·00 per cent.
Alumina combined as normal	15·20 "
Basic alumina=so-called "free"	1·80 "

The $Al_2(SO_4)_3$ calculated from 15·20 per cent. of alumina equals 50·96 per cent., whereas if calculated from 17·00 per cent., the $Al_2(SO_4)_3$ equals 57·00 per cent. In conjunction with these figures it must be borne in mind that experiment proves the basic sulphate of alumina to be relatively even more efficient than the difference in the above interpretations of the analysis indicates.

CARBON IN THE SUN.

WHAT it concerns us specially to notice is that among elements which may be deemed refractory, that is to say, among elements which retain the solid or the liquid state until a temperature has been attained high enough to drive most other substances into vapor, the molecular mass of carbon is exceptionally small. We may, in fact, assert that so far as elements which are likely to exist in abundance on the sun are concerned, the case of carbon is unique. This element combines an excessively high refractory nature with an excessively low molecular mass. It will not be hard to deduce from these facts Dr. Stoney's very remarkable conclusion that carbon is the effective constituent of the clouds in the photosphere. It is, indeed, very interesting to trace out the ingenious line of reasoning by which this conclusion is established. I shall here give an outline of the argument.

Picture the condition of affairs in the upper part of the solar atmosphere, where the vapors of many elements are commingled. At the same distance from the center of the sun we may assume that the temperatures are equal. This being so, the several molecules of the different elements in the mixture will be moving with varied velocities, corresponding on the average to their various molecular weights. Specially noticeable among them will be the molecules of carbon. They are in great abundance, and they are distinguished from the great majority of the substances with which they are associated by the high speed at which they are generally darting along. Their motions are of course pursued in every direction, myriads of molecules are flying downward, myriads are flying horizontally, myriads are flying upward. It is these last which are at present important.

As a molecule is flying upward it experiences not alone all the chance encounters with the other molecules, but it is also directly subjected to a reduction of its velocity in consequence of the gravitation of the sun. That gravitation is vehement in proportion to the great mass of the sun. Thus the attraction of the sun on the molecules must be about twenty-five times the attraction which the earth exerts on bodies near its surface. Those molecules which move comparatively slowly must in their occasional vertical flights respond to the solar attractions more promptly than the molecules better endowed with velocity. It thus appears that, when the molecules of carbon happen to be darting upward and outward from the sun, their comparatively high velocities will enable them to attain generally greater altitude in the solar atmosphere than is permitted to the molecules of a less lively character. Thus we see that the molecules of carbon will on the whole tend to soar aloft to greater altitudes than are attained by the majority of solar materials.

This consideration excludes a number of elements from possible participation in the clouds of the photosphere. Their molecular velocities are not sufficient to maintain them at the necessary altitudes. But among the elements which are permitted to elevate themselves sufficiently, carbon now assumes a distinctly prominent position in virtue of the other remarkable property of this element to which we have referred. It is certain that the greater the distance from the solar center, the lower must be the temperature to which the materials are exposed. No doubt in the interior of the sun the temperature is so high that even carbon must be there permanently gaseous. But at a sufficient altitude above the sun's surface, or to speak more accurately, at a sufficient distance from the sun's center, the temperature is low enough to permit the carbon vapors to return to the liquid state, and thus gather into the beads of liquid glowing carbon which forms the luminous cloud. What then happens is clearly of the following nature. The high velocities of the carbon molecules are ever and anon conducting them to elevations in the

solar atmosphere, where the temperature is sufficiently low to reduce the carbon vapors to the cloudy state which they are so prone assume. Herein lies the essential difference between carbon and the other elements. In the first place, many of the elements never possess sufficient molecular velocities to carry them in any large quantities into the elevated regions. In the second place, among the elements which can attain sufficient altitudes carbon is the most refractory, and therefore would be the first to take that step in condensation implied by its transformation into a cloud. On these grounds Dr. Stoney has concluded that the same element which is the great source of artificial light in almost all forms on this earth, is also the source of solar light. Our conception of the important functions of carbon in the universe is thus greatly extended.—*Sir Robert Ball, in the Fortnightly Review.*

"MISTI"—HARVARD'S NEW OBSERVATORY.

THE volcano, so called, of which we give a view, is situated on a spur of the Andes near Arequipa, Peru. It is notable for its conical figure and for its elevation. It is situated in 16° 17' latitude, and 73° 39' longitude. Its height is a little over 6,000 meters = 19,300 feet. There is no tradition in respect to the epoch in which it was in eruption, but it must have been before the time of the Incas, and it is undoubtedly now extinguished.

Prior to 1858, no one had been able to reach its summit, although Haenke, Pentland and others had made attempts. The first who succeeded was the naturalist Weddell; since then many persons have made the ascent. The ascent is attended with much fatigue, not only by reason of the great elevation, but because the mountain is covered with loose ashes. In August last an expedition was sent out to make the complete circuit of this volcano, with the object of studying the possibility of making a mule road to the top. Minute observations were made with good telescopes of all sides of the mountain, and we took some photographs. Seen from whatever direction, Misti presents a surprising symmetry, always showing a cone more or less truncated, but almost perfect. This examination convinced me the mountain was accessible from the northeast. In August a stone cabin was erected on the northeast side of the volcano as a station, and here I stayed several days watching the construction of the road to the summit. Without leaving the great slopes of volcanic sand and avoiding the sharp rocks, it did not prove to be an impossible enterprise, as many have feared.

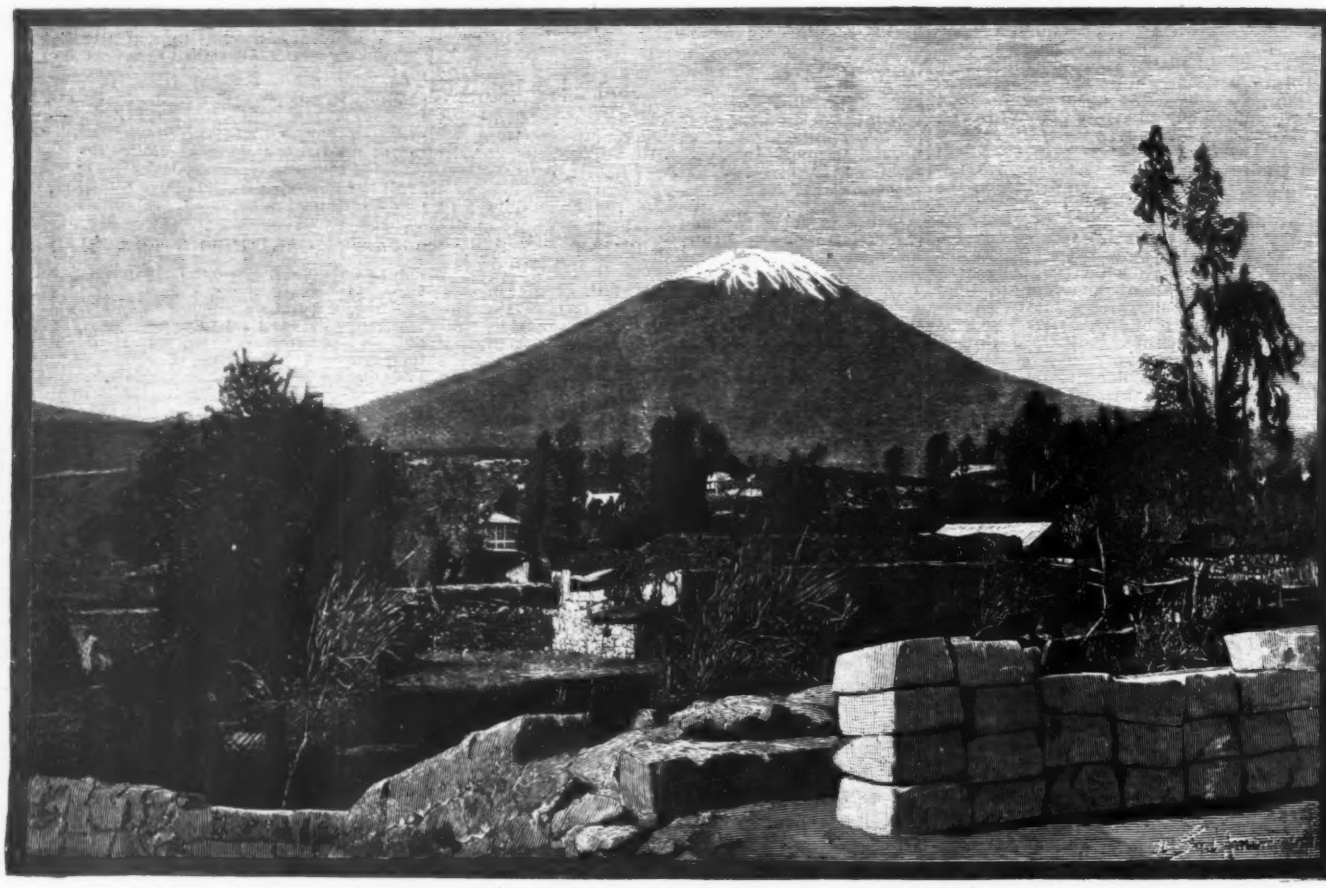
On the 27th of September, 1893, I had the pleasure of reaching the summit with my assistant, several Indians and two mules. Going on foot and on mule back alternately, we arrived in good condition to make scientific observations, and the mules were not seriously injured. The altitude, however, produced a great effect upon the mules, and when near the top they refused to go more than twenty steps at a time without taking a good rest. Without such extreme care, it is probable they would have succumbed.

On the 12th of October I returned to visit the summit with two members of the observatory, twelve Indians, and thirty mules, transporting a portable house of wood, with double walls. We also carried a small house for instruments, together with the instruments necessary for the station work. Provisions were sent to our stone cabin, where we pass the night at an altitude of 16,000 feet, more or less; without this precaution the ascension would have been impossible. Some of the members of the committee suffered seriously from breath exhaustion (*soroche*), and only by great exertions did the men and mules succeed in reaching the summit. In many places it was necessary that two men should assist each of the mules that bore the heavy parts of the house. On this expedition one of the mules stumbled and went down a rocky declivity and was considerably hurt; happily its burden consisted of clothing and other articles which were not damaged by the fall.

The station consists at present of two little houses, one for the observers and the other for the instruments. They have been located at a short distance from the iron cross, which, for more than a century, has formed so fitting a crown for the mountain. The station is provided with an automatic barometer, indicator, thermograph, hygrometer and anemometer, together with various mercurial thermometers. The first named automatic instruments run ten days, and a member of the observatory will visit the station three times a month.

The height of the station, according to determinations made by various barometric observations, is 19,300 feet above the level of the sea.

For the government and citizens of the country who have so generously lent their assistance and confidence to this observatory, it ought to be a matter of pride that Peru not only possesses some of the sublimest scenery, but also has given to science the highest meteorological station in the world.



"MISTI," HARVARD'S NEW OBSERVATORY.

The crater is encompassed by a species of granite wall, which forms a great basin in the shape of a funnel, filled in the center with ashes. So says *La Ilustracion Sud Americana*, from which our engraving is taken.

Misti is now occupied as a meteorological station by Harvard University.

We are indebted to Dr. S. I. Bailey, of the Harvard Observatory, Arequipa, Peru, for a copy of *La Bolsa*, of that city, containing an account by him of the establishment of the Harvard Meteorological Station on the summit of Misti, not far from Arequipa.

We translate the following abstract: Well knowing the interest which Peruvians take in scientific progress, and especially in all observations made in connection with the famous volcano of Arequipa, I have the pleasure of giving you the following particulars concerning the meteorological station recently established on the summit of Misti. In order to equip and put this station into operation, a road for mules was very much desired; for, although one might be able to go on foot to the summit once or twice, it would be very difficult, without such a road, for an intelligent person to visit the station regularly and make the necessary observations. The experience of persons who have ascended to great heights has been, in general, that the fatigue due to the extraordinary exertions has disabled them from making exact observations. We have never heard it said that mules have ascended to so great a height as the summit of Misti; but previous experience with these animals at heights of 17,000 feet convinced me that, with proper care, mules might ascend to a height of 19,000 or even 20,000 feet.

Of all the mountains in the neighborhood of Arequipa, Misti, by its splendid isolation and symmetry, is the most adequate for a prominent meteorological station.

TRIPOLI IN THE SPRING.

A VISIT to Tripoli in the mouth of March is as delightful a holiday as any one need wish for. The intense heat of summer has not yet set in, and you experience the warmth of our July, combined with a brighter sunshine. Tripoli occupies an oasis on the edge of the Great Desert; outside the walled town a fertile sandy tract of land extends along the shore for some miles, and here you revel amid many novel and marvelous sights. There are miles of palm groves where the trees tower up as straight as ships' masts, and where the dates will soon hang in huge clusters from the feathery crowns. There are vast tracts of orange gardens, where you may for a few pence wander among fragrant groves, plucking and eating the luscious golden fruit as it hangs above your head. There is but little or no tide at Tripoli, and the bright strip of golden shore is like a moving panorama of pictures, such as we never see in our northern clime. Camels are here by the hundred, lying down, roaring, and chewing the cud, or walking along with stately pace, head high in the air; ragged, ill-favored camels; camels with rich, thick, brown fur or hair; light colored, dark, old and young. The Arabs, swathed from head to foot in blankets, ride or walk alongside, with long fowling pieces over their shoulders.

Negroes there are in plenty, and of the blackest hue, from the far Soudan, jolly-looking and merry, and, perchance, clothed in many-colored rags. The esparto grass forms one of the chief articles of trade between Tripoli and England. It is found in the desert a few days' journey from Tripoli. Long strings of camels may be constantly seen on the shore making for the various esparto yards, each camel carrying about three cwt. of grass. The negroes are good steady workers; they pick the grass, throwing out the bad. It is packed into close bales by hydraulic pressure, bound round with iron bands, and is shipped off in steamers to England, where it is converted into paper. The negroes live in colonies among the palm trees, and a visit to their quarters reminds one of books of travel by African explorers. The huts are like beehives in shape, and are entered in the same way by a low half-round doorway. Each hut owns a small plot of ground which is surrounded by palisading, *a la* Robinson Crusoe, and many of the owners jealously close the door on the appearance of a stranger. The women of the family sit about on the ground making colored baskets, while their charming black babies roll about on the sandy ground enjoying life to the full.

A walk of two or three miles across the breadth of Tripoli brings you to the edge of the Great Desert, the most wonderful sight of the many that Tripoli can furnish. Here you may stand among the palm trees, gazing over a waste of sand, with its distant mountain ridge, a great arid plain, extending away "for six months." Such a vast extent of utter loneliness is awe-inspiring, and it may be revisited again and again without losing its fascinating charm. As you stand gazing over this limitless, uneven plain of sand a few dark specks appear on the horizon; gradually they draw nearer, winding along like a great black snake; and soon you distinguish the forms of many camels loaded with esparto grass, their Arab owners walking alongside through the hot sand and under a scorching sun. They enter the fringe of palm trees, and another hour will bring them to their journey's end. The sun is setting, and the scene grows in solemnity, not a bird nor an animal to break the silence; only the burning waste of sand stretching away "for six months." Twilight falls; a crimson flush spreads over the horizon, extending over the sky, and gradually blending through an infinite variety of colors with the deep blue overhead. So we turn away from the edge of the Great Desert of Sahara to wander back to Tripoli through the darkening lanes, under the shadows of the tall, ghostly palm trees.—*The Graphic, London.*

CŒLOGYNE MOSSIÆ.

ROLFE, *n. sp.*

OUR illustration affords a representation of the pretty and new Cœlogyne, which was exhibited by J. S. Moss, Esq., Wintershill, Bishop's Waltham, Hants (gardener, Mr. Bazeley), at the Royal Horticultural Society's meeting of the orchid committee on March 13, when it was awarded a first-class certificate. Its spray of white flowers was much admired, and it was duly noticed in our issue of March 17.

Like many another fine introduction, it is to an amateur's endeavors that the arrival of this pretty plant in our gardens is due. It was sent to Mr. Moss by a friend in the Neilgherry district, of India, in 1887; two plants coming in a box with some other orchids. It bloomed for the first time in 1890, but it was not until recently that it got named. At present there are four plants of it, and some back bulbs which may make another, but we trust that a larger importation of the species will be made, so that it may be distributed, and take that place in gardens which its beauty entitles it to.—*The Gardeners' Chronicle.*

CŒLOGYNE MOSSIÆ, ROLFE, *ined.* FLOWERS WHITE.

THE WORLD'S COLUMBIAN EXPOSITION FROM A BOTANICAL STANDPOINT.*

By HENRY KRAEMER.

THE botany of the World's Columbian Exposition may be said to have been a subject of at least some interest to every one that visited the Fair. And while attention has been called to the fact that in only three places in the great Exposition did one see the placard with the name "Botany," still it was important and noteworthy that three buildings were entirely devoted to the exhibition of some of the products of the vegetable kingdom and that all of the others contained more or less exhibits of a botanical nature. Much may be said regarding the momentary inspiration one received upon beholding the building and grounds for the first time. It might be compared to that of an ideal realized and personified. In reality it was akin to that which one receives upon beholding a young man (say on his commencement day) whose powers are not only strong, but whose pecuniary position is as strong and whose every action is a story of ideal endeavors and splendid successes.

In endeavoring to select that which will be of interest to us and of bearing upon our subject to-day we must forego mention, certainly in detail, of those objects which are likely to be seen again or are of a purely external character. For convenience let us first look into that building which was one of the most conspicuous at the Exposition—the Agricultural building. In this building 37 of the States of the United States and 35 foreign nations had exhibits. The nations and States participating utilized their principal products in the construction and ornamentations of their pavilions. The medicinal specimens were not, generally speaking, of much interest, not so much because these were not interesting exhibits, but mainly because the arrangement, labeling and nomenclature were so poor that it was difficult without considerable labor to obtain even the slightest information relating thereto. Mention may be made of eucalyptus oils; an assorted Cape gum, being an exudation from Acacia horrida; a solid block of Cape aloes, 18 inches wide, 2 feet high and 1 foot thick. Several blocks of honey and wax of about 50 pounds each. Rolls of cinnamon, with cinnamon peelers' tools.

More attention was paid to the agricultural and economic side of botany than to the medicinal side. Woods of all kinds were displayed, being worked up and polished to show their especial adaptability to all kinds of ornamental and useful work. An interesting product was a quantity of cassava bread (see *Amer. Jour. Pharm.*, 1891, 391). Canada exhibited a section of Prunus virginiana, 44 inches in diameter. Ceylon exhibited tea and coffee from more than 100 estates, one sample of tea being valued at $175 per pound. Germany exhibited the processes for, and products resulting from, the manufacture of sugar from the beet root, of spirit from potatoes, of starch from potatoes, of starch sugar by the inversion of potato starch, of the manufacture of pressed yeast; also those of malt making, beer brewing, and vinegar manufacture. These are industries involving botanical questions and belong to the department of physiological botany. The time is fast approaching when botany will be recognized by the biologists and chemists to its fullest extent and given credit for all its work. That this is already the case with the biologists, we need but to recall the recent discussions and examine the prospecti of some of our leading universities during the past year. In some of the "chemical" industries biologists (botanical biologists) are absolutely necessary for the production of good products. An object of special interest in the German exhibit was a pavilion of chocolate 30 feet high and made of 30,000 pounds of material!

The Japanese showed a spirit of enterprise which was possibly unsurpassed by any country or State. Rice was abundantly shown in all its varieties. The glutinous rice is chiefly consumed by making it into the form of cakes, called "Mochi." Upland rice or "Okato" is, generally speaking, far inferior in its taste when cooked to that of the ordinary rice grown in paddy fields, although there is but little difference between them in chemical composition. Many of the products of rice were exhibited. An interesting cultivated plant was Yegoma (Perilla ocimoides), which yielded 17 per cent. of a drying oil, which has the property, when mixed with other oils, that solidify in the cold easily (as rape seed), of preventing their freezing. The products of haze fruit and lacquer fruit were also shown.

Among fibers may be mentioned *Mao fiber*, the production of Boehmeria nilvea, and *Banana fiber*, the product of Musa basjoo. The fiber of Mao excels that of hemp by its flexibility, fineness and high luster. The finest quality is consumed in the weaving of costly cloth, which is highly esteemed by the Japanese for summer dresses. The poorer quality being used for making fishing nets, angling lines, etc.

Among barks used in paper making were exhibited the *Paper Mulberry* (Broussonetia papyrifera), *Mitsumata bark* (Edgeworthia papyrifera), and *Ganpi bark* (Wickstrœmia canescens). Specimens of raw and bleached bark with specimens of paper were exhibited. The Ganpi bark is valued especially in producing a smooth, fine, and high-lustered paper. Japanese paper is usually made from two or more raw materials, and is very seldom prepared from a single material. Moreover, the fiber of Ganpi and Mitsumata are not strong enough singly, yet they are extensively used with other coarse raw materials in order to give the tenderness, smoothness, and luster to paper of low quality.

Tobacco from nine prefectures was exhibited. The product of Kokubu is most highly esteemed by the Japanese. There were also exhibited some fine specimens of peppermint oil and menthol crystals. These products are yielded by Mentha arvensis, a plant cultivated from a very remote age in Japan. All the specimens exhibited came from the Yamagata prefecture, from which the exported products are also obtained.

In cultivating the plants the land is well prepared in the month of October, and the roots separated from the stubble are cut to lengths and planted in well-prepared soil in rows. In the next spring a dilute ordure is given the plants, when they grow vigorously. The first cutting is done in the middle of July, the second in the middle of September, and sometimes, but rarely, a third cutting is made in some districts. The plant is dried under a shed without exposing to the sun and carefully kept for future distilling. The best time for distilling is said to be the middle of January.

Among edible dried products of plants may be mentioned the dried sweet potato. For preparing this a certain quantity of cleanly washed potatoes are placed in a suitable basket and immersed in boiling water for a short time, then removed from the basket, cut into thin slices, spread over mats and exposed to the sun for two or three days. A superior quality is obtained by peeling off the skins before slicing. Other dried products were exhibited.

Summing up the products exhibited in this building, we mention that tobacco in all its forms was displayed with machines and appliances for curing it and manufacturing cigars, cigarettes and snuff, as well as insecticides and methods with appliances used to endeavor to stay the ravages of the tobacco worm and other parasites. Cotton on the stalk was shown in all its varieties; with methods of planting and cultivating, as well as the methods and machines used in picking, ginning and baling it. Likewise hemp, flax, jute, ramie and other vegetable fibers were displayed in their primitive forms and in all stages of spinning. Malt liquors with machinery and processes employed in fermenting, distilling, bottling and storing these beverages. Models of breweries in operation. Among vegetable oils were cotton seed, olive, rape seed, linseed, palm, etc., with the seeds and seed cakes as residues. Starches were exhibited with processes of manufacture from all sources, from cereals, tubers, arrowroot, plantain, cassava, zamia, manioca, tapioca, sago, pearl, flour, etc. Sugar cane, beet root and sorghum were exhibited in the raw and natural condition with the processes which finally yielded the commercial sirups and sugars. Sugars from palms, maple and milk were exhibited. To the agriculturist the different State exhibits were of interest, as the hives with the many varieties of Apis mellifica were displayed with all the modern appliances in the production of honey and wax. Some of the fertilizers of fossil and animal origin were of some degree of interest and of great importance. The exhibits of food stuffs were displayed in many instances in a striking manner.

The seed displays were divided between the Horticultural and Agricultural buildings. In the latter the field seeds were supposed to be shown to the greater or less exclusion of the garden seeds. The display of a firm of Paris (Vilmorin-Andrieux et Cie.), in the French section, was in the nature of a well ordered botanical museum. On the walls were hung panels of wheat, specimen charts showing the sugar yield of beets and the starch yield of potatoes, and illustrations of their farms. They had fourteen glass cases with models or casts of representative types of vegetables and strawberries. With the exception of a small collection of photographs in the alcoves of the Experimental Stations Exhibit, here seemed to be the only attempt to show anything of the results of hybridization. The name of Vilmorin has long been connected with experiments on the crossing of wheats, and some of the graphic results were shown in small sheaves mounted upon tastefully framed green felt. Here were exhibited, also, models of representative average and normal forms of vegetables. The prime value of these models with their excellent arrangement was that it afforded the student a means fixing the conventional standard or type and illustrating the chief lines of development and variation as arising therefrom. Two of the specimen charts were unique. One comprised six glass tubes about an inch in diameter and five feet long, containing proportionate amounts of "sugar in the juice" and refined sugar in the leading sugar beets. A similar chart displayed the starch yield from the varieties of potatoes. Altogether the exhibit was just such a one as a teacher of economic botany ought to possess in his museum and use in his teachings.

The Japanese garden was considered the unique feature, and has been acknowledged as a good example of Japanese art. It was 22 × 141 feet in extent and comprised 2,000 distinct plants. It was intended to represent such a garden as is to be seen adjacent to a dwelling house. Here were the hillocks, the cascades, the stone lamps, the sheet of water and the summer houses hidden in the clump of trees. Upon either side of the central walk were a miscellaneous collection of plants, so thickly planted as to nearly hide the earth. This walk passed over an arched bridge, which was peculiar in its construction. In the rear were blue and green sprays of Juniperus littoralis projecting over the water, while in front were large and small azaleas, ferns and red-berried adrisias. Among some of the interesting plants from Japan was a Thuja orientalis, about 3 feet high and 8 inches thick at the base. It was reported to be 100 years old, but its growth was so curtailed and dwarfed that it appeared as a very small shrub. In order to produce this result, the limbs of the trees are tied with ligatures, and at the same time they are placed in such positions that they will grow into the most fantastic shapes imaginable. The result is we have some trees reduced in size and presenting almost as hideous an appearance, compared to the original, as would a human being whose limbs and body were dwarfed, tortured and twisted out of all shape. A number of the genera were thus represented. One cypress, reputed to be 300 years old, perished with the cold of the previous winter. Some of the ancient crooked maples were but a foot high, in some of which every leaf had been carefully trained and others bore several varieties on the same top. A pine tree was exhibited with gnarled branches and massive roots. In some of the pines the needles were held in place to produce a fine cushiony effect that is so highly prized.

The azaleas exhibited were of much interest. The most striking ones were large and free-growing bushes of Azalea indica, which earlier bore single dull red and pink flowers. One variety in particular, called Mitsu-somekuruma, attracted considerable attention on account of its very small greenish white flowers. There were exhibited also several varieties of the Ghent type. Here were two exceedingly curious forms reduced to five separate and long strap-shaped divisions. In one instance of the mollis type, the petals were red and spotted and the stamens were wanting. Another of the Indica type possessed dull pink or red petals and long red filaments entirely barren of anthers, giving the flower a strange, spidery look.

Proceeding to the viticultural displays, we saw a most decorative sight, although there was but little genuine horticulture in it. In considering the grape interests, it would be well to divide the subject into two parts, as the Italians and some others have done:

* Abstract of paper read at Pharmaceutical meeting, Dec. 19, 1893.—*Am. Jour. Pharm.*

viticulture or grape growing and viniculture or wine making. Viticulture was shown by illustrations of the vine and its varieties in natural and artificial ways by cuttings, engravings and photographs. Methods of planting, staking and training the vine were to be observed, as well as the methods of and appliances for cultivating, harvesting, curing, packing and shipping the grapes. On the other hand, viniculture was demonstrated by the methods employed in expressing the juice of the grape; of fermenting, storing, racking and bottling, and finally shipping the wine.

The Deutsche Wein Austellung contained a larger variety of hands and number of exhibitors than that of any other wine exhibition in the Exposition. The German Wine building was built in the form of a cloister cellar. The interior space being occupied with tables and stands of wine in bottles, being the combined exhibition of 289 growers and dealers of the German empire. The arrangement wae simple, but the chief attraction lay beyond, upon the eastern and southern walls. Upon these sides, in the form of panorama, some of the most striking of the wine regions of Germany were depicted. One looked as from a porch upon a landscape of remarkable picturesqueness, and the effect was greatly heightened by the plantations of grapevines in the foreground. These grapevines were the actual plants brought from the neighborhoods represented upon canvas and set in the earth as they customarily grow. Of course the vines themselves were not living, but were, however, dexterously clothed with artificial leaves and fruits, so that they almost perfectly represented the growing and bearing vine. As each of the panoramas represented a distinct wine district, so the wines in each of the foregrounds showed the exact method of training employed in those districts, and the artificial fruits and leaves represented the varieties grown there. There were many panoramas in the exposition, and there were none more perfect, nor probably more interesting (unless it was that in the Electrical building), than these of the German Wine building.

California's exhibit occupied nearly one-fourth of the ground floor space of this department. It was certainly with a feeling of pride that we viewed the efforts and progress of this comparatively young industry in the United States. One of the most notable pavilions was erected by four companies of wine producers. It was constructed of a section of a giant sequoia, which was 30 feet in diameter at the base and 290 feet high. Growing up from the base of the tree were grapevines, with an abundance of ripe fruit hanging from the vines. In the interior were the exhibits of the four prominent houses. The exhibit of the vineyard of the late Senator Stanford showed, in a perspective view, the natural size of a section of the cellars of the vineyard, which have a storage capacity of 5,000,000 gallons. This vineyard is probably the largest in the world, containing 3,840 acres, and producing annually 16,000 tons of grapes. Besides the exhibits of 25 smaller firms, the State Board of Viticulture had an instructive exhibit of photographs, engravings, etc., showing methods of cultivation of vine, etc.

The Japanese had a small exhibit. One sample of wine called "Seijyunbudosyn" was labeled with the following: "This wine can be recommended, as nothing equals it under the sun." The Italians were represented by 130 firms displaying 560 brands of wine, the oldest vintage of record being that of 1812. The Russian Imperial Appanages exhibited a model of one of the principal wine cellars of an estate in the Caucasus with a capacity of about 432,000 gallons. There were some interesting exhibits by a number of exhibitors of woods, herbarium and seed specimens, with photographs of the grapes and in some cases a display of the grapes themselves. Vitis Linceeumii, Buckley, and its hybrids, seemed to attract some attention as being a source of fine quality of grape.

Among the fruits, those of the citrus genus constituted one of the greatest attractions of the fair. The largest single exhibit consisted of a column thirty-five feet high, covered with nearly fourteen thousand oranges and some lemons. Lemon growing, while a comparatively recent industry in America, is looked upon as a paying product by the Californian people. The most remarkable as well as the most handsome lemon in the exhibit was the "Bonnie Bræ," shown in the display of San Diego. It was long and smooth and possessed a short tip, a thin skin, and was seedless. The fruit of Florida is earlier than that of California, but seems to keep better.

The lawns about the Horticultural building were well provided and represented by some of the products of the leading botanical gardens of the world. The original design of having them bloom in their season was wondrously carried out. During May the azaleas excited the admiration of the spectators, as their flames of color eclipsed that of all other plants flowering at that time. In early June 10,000 rhododendrons were the chief attraction. They are probably the most showy plant, and carry with them an air of massiveness and stability which makes them beautiful During June and July some 50,000 roses, including over 2,000 varieties, were most conspicuous, and again "carried the day" and days. Was not this wonderfully suggestive? The roses of the world were here flowering at one and the same time, and saying, peace, my peace, our peace we give unto each other. Later came the cannas with their fiery plumes, and then followed the chrysanthemums and cosmos, the much prized and fashionable flowers of early spring. Besides these many other flowers were in bloom.

In the Manufactures and Liberal Arts building were a number of botanical exhibits Of particular interest were the colored models and charts exhibited by Germany and Japan. The petrified wood specimens from the forests of Arizona were indeed large and beautiful. Ice coolers, fountains, mantels, table tops, and many ornaments were made therefrom. We were much interested in the ornamental application of the products of the Cactaceæ. It has recently been found that the cacti growing at different altitudes vary widely as to their general structure; that those, for instance, growing in high altitudes possess a finer grain than the same specimens growing in the valleys. The wood of the former being more compact and not so porous, has been found to be admirably adapted to the manufacture of a variety of ornamental articles. For manner of treatment of wood, etc., see SCIENTIFIC AMERICAN.

The exhibit of New South Wales was large and instructive. The Technological museum, under the direction of J. H. Maiden, having arranged every exhibit with full descriptions and applications. In this manner were displayed the economic plants, the substances used as food chiefly by the aborigines, gums, resins, and kinos from indigenous plants, tan barks, a miscellaneous collection of barks of economic value, indigenous fibers, galls, and specimens of Australian economic entomology.

There was also a case of fibers handsomely mounted, twenty fine illustrations, ten by twelve inches, very faithfully colored, from a forthcoming work on North American fleshy fungi, by Farlow, and a set of the published writings of Dr. Gray.

In the department of pharmacognosy the Pharmacy Department of the University of Michigan was the only institution that endeavored to show to the world the work she was doing. I was much impressed with her display of herbarium specimens of plants in connection with commercial samples of the various parts employed in medicine. In a similar manner were displayed many of our prominent plant drugs, as rheum, kola, mate, guarana, tea, coffee, guaiac, cubebs, nux vomica, ignatia, etc., with their chemical constituents. A capital "kindergarten" idea for a student's museum.

Coming to the State buildings, we find that many of them were not erected for exhibition purposes, but simply a kind of a club house, for the use of both men and women. Some few, however, were exceedingly energetic, and their displays were not only interesting but instructive. Illinois being, in a sense, the host of the Exposition, had by far the most portentous structure. It was constructed almost entirely of the products of Illinois. The agricultural exhibit was very large. Upon one of the walls was a most ingenious work of art. It consisted of a typical farm scene, with houses, animals, fields crops, workmen, etc., made from the products of the State. The whole gives the idea of an oil painting, so perfectly had the blending of colors from the natural grains and grasses been made. Upon one side of the frame was a heavy drapery, giving the effect of silk, it also being made of different grasses.

The exhibition relating to botany was probably the most complete exhibit illustrating the teaching of botany to be found at the Exposition. There was to be found a working desk equipped for an undergraduate student and another for an advanced investigator; also a series of microscopes formerly used in contrast with those now used; also sets of permanent mounts, reagents, and stains employed, apparatus for photomicrography with photomicrographic enlargements, a very full bacteriological outfit with living cultures, an herbarium, etc. The Experiment Station exhibited a long case showing the diseases of cultivated plants and a collection of seeds of wild plants. Outside of the university exhibit there was a pavilion constructed of all the different woods grown in the State. Inside were sample- illustrating the varied uses to which the various woods are put. There was another pavilion constructed of the products of the corn. The very uprights were grown in a cornfield, the roof being a thatch of stalks. All the decorations are typical of corn; the silky tassels served for frieze and dado, while the corn in the ear was arranged according to combinations of colors into many fantastic designs.

The State of Washington made a creditable exhibit. In front of the building was a mast, being a straight piece of fir, 3½ feet in diameter at the base and 215 feet high. The south and north wings each rested upon one piece of timber, 3 by 3½ feet and 125 feet long. Each of these pieces was cut from a yellow fir tree 7 feet 11 inches in diameter and 340 feet high. There was a life size full length of Washington, which had a frame made entirely of small pieces of wood, being inlaid with seventy-seven different kinds of wood found in the State. Besides an interesting agricultural exhibit, there was one of the best herbaria to be found in the Exposition, in that the collector had given considerable information upon the labels regarding the occurrence of the species exhibited.

To the systematic botanist, the herbarium specimens, illustrative of the flora of Minnesota, Colorado, Montana, Missouri, Kentucky, Wisconsin, etc., were of considerable interest. In the construction of their buildings and in their displays the Western States, more particularly the younger States, realized that this was their opportunity of making known to the world their individual natural resources. They endeavored to, and succeeded well in many instances in so arranging their products that it would strike the heart of the home seeker of limited means and the pocketbook of the capitalist seeking fields for the investment of his superabundance. Before closing this part of the description of the Exposition, reference should be made to the excellent collection of cacti in the Territorial (Arizona, Oklahoma, and New Mexico) building. Here was a Cereus giganteus or "Sahura," as it is called, some fifteen feet high, possessing a cristate top some four feet broad. Coming to that of Ceylon, we learn that her "courts" were constructed entirely of native wood. Here was the principal exhibit of her tea, and much valuable information could be obtained from the publication of Ceylon and from the attendants. In the Merck building were thirty-six wax models of medicinal plants. A number of specimens of opium, with scarificators and knives employed in obtaining the gum. Even in Midway Plaisance were some things of botanical interest to be found. Here the groves of orange and lemon trees, the Samoan houses, and the Javanese village.

In conclusion, we referred to the momentary inspiration upon seeing that magnificent collection of buildings at the Columbian Exposition as being akin to that when beholding a young man upon his commencement day—surrounded by the rainbow of promise. This Exposition which we have seen was really but the repetition of a commencement day's experience. We long before anticipated a supreme pleasure as we thought of going from one exhibit to another, collecting data and securing information from every available source of the world upon botanical matters. In this we had a similar experience and disappointment to J. C. Arthur, of Purdue University, who wrote (*Botanical Gazette*, September, 1893) that "there is considerable material through the Exposition of interest to botanists, but it is so widely separated and, in the main, so difficult to find that it is likely to be largely missed by those who would receive the most benefit from the display." Also, "very few of the exhibits are accompanied by adequate information, sometimes they are entirely unlabeled, and, as a rule, the attendants, if they can be found, can add little, if anything." This was to be expected, perhaps, in that the Exposition was a general exhibition. The managers, certainly, of the botanical part evidently did not appreciate the details nor impress others with the possibilities that were here presented for a most remarkable and unprecedented educational exhibit of scientific methods and results. Here, as in so many other cases, the evil was increased by the perversion of the public taste, which causes works to be admired, not in proportion to their fitness for their purposes or the skill evinced in attaining that fitness, but in proportion to their size and cost.

The last quarter of this century has witnessed a most remarkable development of specialization of labor. With the death of Mr. Darwin, we might say, was the extinguishment of the last scientific light that was able to illuminate equally well any and all departments of science. And, as for the affairs of the world at large, it has been many centuries since we have had the men of whom it might be said, "They have mastered all the knowledge of this day." And so in this discussion of the botany of the World's Fair, while we criticise (for to discuss was to criticise) we do not belittle the efforts of these gentlemen, for, under the circumstances, we do not feel possibly that we ought to have expected of them more than we do of a student upon his commencement day.

We hope that this is the last of the great general world's fairs. They may be very interesting and of some profit (like the displays in our large stores during the holiday season) to the average mind, but they do not receive the support or the attention of the highest intellects in the contribution of their best work. And this best work in every department where skill is demanded will at the same time do the average person infinitely more good (just as a college education) than the showy and often tastily executed exhibits of a general nature, attended with simply one's own interpretation, are largely intended as a means of commercial advertising. It is not my purpose at this meeting to expand upon this subject, but suffice it to say that we believe there should be in the future expositions having more a *specific character*. In the exposition of a scientific nature there should be a council composed of the most renowned and most capable scientific men, who should be given sufficient time and who should have the same means at their disposal as this Exposition committee for securing the contributions and support of the best institutions, societies, and individuals of the world. Furthermore, these exhibitions should be periodic and yet, in a certain sense, made as permanent as possible, so that additions and corrections should be made (similar to the committee of the U. S. P.) We are aware of many objections that may be raised, but these, in time, after reflection, might, too, vanish like the stagnant pools and marshes in the suburbs of Chicago upon which the White City was built.

By way of further suggestion, let us see what a world's botanical exposition might contain. One building might be devoted to the interests of morphological and systematic botany. Here could be displayed the models, charts, and methods illustrating the study of morphology. Also the different methods of collecting, drying, preserving and classifying plants. Laboratories might be equipped and work shown with information thereupon given. A similar exhibit might be made in the building devoted to anatomical and physiological botany. In the building devoted to medical botany, an exhibition (as interesting as that in the Manufactures and Liberal Arts building might be made), consisting of panoramas and illustrations of the cultivation, collection, preparation, with specimens, etc., of our important and interesting vegetable drugs. There would be other buildings illustrating horticulture, arboriculture, viticulture, viniculture, agriculture, geographical and fossil botany, as well as the other industrial, ornamental, and economical sides of botany.

It must be apparent that an exposition of this kind, botanically, would be, if properly managed, of a highly instructive and most interesting character to the world. The name of some one or of some event of world-wide importance would be necessary to arouse the interest in such an exposition. Might not the name of Linnæus do this? Is it too much to hope that the next world's exposition might be a botanical exhibition and called the World's Linnæan Exposition, to be held beginning May 23, 2007, in honor of the third centennial anniversary of the birth of Linnæus?

DEVELOPMENT OF MINERALOGY—III.

By L. P. GRATACAP.

THE Arabians fostered learning, and from the East invaded occidental Europe with the heritage of Grecian speculation. They became the schoolmen of the continent, and enlightened the Christian schools in the rudiments and methods of astronomical and medical science. Their zeal in philosophy, their spirit of aquisitive curiosity and their keen application, soon gave distinction to their academies, and extended the influence of them far beyond the limits of the Moslem realm. Among these Avicenna (Ibn Sina), born in 980, and dying in 1037, contributed to the expansion of mineralogical science, or at least kept alive the interest in scientific studies from which, in its general aspects, mineralogy received a subordinate return. He was an Arabian physician, learned in the books of his time, in Aristotle, Euclid, Ptolemy, Galen, and animated by that thirst for knowledge which then appeared so strenuous among the Arabians. It impelled him and his great successor, Averrhoes, to traverse the field of human knowledge as then developed, and envelop their own speculations in the dress of that pseudo-scientific pretense to system which was the heritage of science from the classical period. At twenty-one he prepared an encyclopedia in which was reproduced all that he had read. His works are mostly medical, but there appears in them references to natural objects, and as many of the ordinary oxides were themselves useful in medicine, some narration may be found in his books concerning their localities and prop-

erties ("De Tinctura Metallorum, Declaratio Lapidis Physici").

In his "Conglutinatione Lapidum" geological science in some of its most prominent principles receives a singularly perspicuous definition, as in the origin of mountains, and the influence of aqueous erosion and deposition.

Averrhoes (Ibn Raschd) was born in 1120 and died in 1198. He exceeded in intellect his predecessor, and displayed a broader philosophical temperament, without as much acuteness of perception. He was deeply versed in Aristotle, and prepared an elaborate commentary and abridgment of the great pagan thinker. In "De Substantia Orbis," he treated of the texture of the earth and gathered together the utterances of his predecessors. The contributions to the development of minerological science of these distinguished Arabians, whose fame perhaps very much exceeds their merit, was more felt in its temperamental than its positive character. They kept alive science and so facilitated the growth of observation and of the spirit and enthusiasm for natural investigation.

In the sixteenth century appeared at Lubec, and subsequently at Leipsic, the famous metrical essay on gems in Latin, by Bishop Marbodus, Bishop of Rennes, written in the eleventh century. This curious production, which incorporated the various picturesque legends which time, fancy, and superstition had associated with precious stones, was utterly devoid of scientific importance. The pages of Pliny supplied much of it, and the writings of Isidorus, Bishop of Seville, who, in 630, wrote on precious stones, were also poetically reproduced in its rather listless and mechanical lines. This poem claims an earlier origin in the work of Evax, King of Arabia, who wrote to the Emperor Nero on the subject of stones, their names, colors, localities, abundance, and potency. It certainly has considerable antiquarian interest, and embodies that childlike and wondering element of thought which invested, in those credulous days, every fable with importance and every object of value with magic. The writer ventures, in rather free doggerel translation, to introduce the reader to some portions of this "Lapidarium," so far at least as to enable him to realize the mineralogical "point of view" of that early time.

Of jasper our melodious lapidary sings:

Ten and seven species of jasper are found,
Differing in color all the world round;
Hither and thither over the earth.
The green and translucent are best in their birth;
Worn chastely, fevers and pestilence fly,
And women in childbirth are helped thereby.
'Tis believed to bring safety, and as it is writ,
Expels the black fancies which o'er the mind sit;
While furnished with silver, around it enframed,
'Tis most potent to help the sick and enchained.

Sapphire—whatever may have been exactly indicated by sapphirus—is thus distinguished for its abundant talismanic qualities:

Sapphire, of gems, most apt for royal eyes,
Gloriously shining, most like the azure skies,
Inferior to none, in virtues and in beauty,
Is called by many the Stone of the Systites;
Since mixed with Libyan sands in wild confusion
'Tis found, by driving waves on beaches in profusion;
Though that most sovereign which the Medians bear,
Which yet, opaque, should lesser honors share.
This stone by potent Nature well endowed
Is sacred called, and gem of gems allowed;
For still the human body young it keeps,
And he unbrokenly who wears it sleeps.
Envy it overcomes, and by no terror shaken
Bolts it unlocks, chains breaks, and prisoners awaken.
It soothes the gods, and brings response to prayer.
'Tis said, for reconciliation, good to bear.
And still more dear Cynthia loves this gem,
And grants to all who wear it her amen!
For corporeal ills this stone is ample cure,
The fever's flame its coldness cannot endure;
It brightens still the eyes, removes the ache
Of listless head, and mixed with milk, the ulcerous cake,
While stumbling tongue it helps to speak;
But he who wears it chaste must keep.

Two more examples from this unique work may suffice to gratify the curiosity of the reader or perhaps furnish him inducements strong enough to read the original poem, which, in spite of its utter dearth of sentiment, is curiously interesting. The first extract is a description of beryl, in which at the outset its six-sided (hexagonal) form is alluded to, and the second refers to the tradition of the glacial origin of quartz, with an expressed doubt whether this time-honored inference is unexceptionally true.

Conspicuous the six-angled stem reveals
The beryl; which, unless colorless, conceals
A violet tint, or else the sea-green wave
Seems shining there, as seen within a cave.
This stone from India comes, a token,
'Tis said to help the love of married men.
Though they that wear it fall to boasting,
And tightly squeezed the hand seems roasting.
The water that laves its sides wherein it lies
Will bring refreshment to ailing eyes.
Or drunk, will quickly all the lungs renew
And cure the troubles of the liver too.

The lines devoted to quartz (*crystallum*) are as follows:

The crystal hardened by long-enduring cold,
As some have written, others sagely told,
Still to our eye reflects the color of the ice,
Though this is doubted as a fact precise.
Since, so they say, in warmer climates too,
The crystal rock with equal beauty grew,
Yet this is fixed, nor mixed with doubt,
That when against the sun 'tis turned about,
It conjures fire, and dry weeds enflames,
This is most clear, and chief among its claims;
And also mixed with honey by matrons used,
The breasts with milk are then suffused.

For the most part, this celebrated poem confines its treatment, as might be expected, to those associations with gems and valuable stones which recall their virtues in sickness, or peculiar subtile emanations, whose efficacy their owners derived from wearing them. Many stones are mentioned whose identification is extremely doubtful or impossible, as the *Galactida*, the Medean stone, *Chelonitis*, *Orites*, *Hyaenia*, *Enydros*, *Pantheron*, *Apistos*, and others; obscure mineralogical aggregates, or stones perhaps, which in some cases obtained distinction from their water-polished surfaces or chance brilliant coloration.

In the twelfth century Mohammed ben Mansur prepared an elaborate treatise on stones in which his own observations were plentifully incorporated. This was followed by the writings of Albertus Magnus, who living in the thirteenth and fourteenth centuries, first insisted on the importance of form and began those speculations as to the origin and essential substance of minerals which brought him into reflections upon the crystalline condition and fixed constitution of mineral species. He wrote ("De Mineralibus et Rebus Metallicis") "it is therefore certain that stones (minerals) have fixed forms and species. These forms are not spirits, for life is essential to spirit. If they make use of nourishment, they should be provided with porous avenues through which such nourishment might be merged, assimilated in them. Neither is it conveniently considered, since the spirit of a stone may then be oppressed by terrestrial inclosure, and thus unable to exercise life and sense, as many physiologists aver, since their nature would be deficient in necessary parts by not giving organs to stones, by which she should expedite their necessary operations. Stones therefore have not spirits, *but they have substantial forms endowed with celestial virtues and a commixture of proper elements.*"

Here we discern the glimmering or awakening of thought in relation to the nature of minerals. They were no longer inorganic groups of physical qualities, accidents of location, or partial reflections of human definitions. Their interior state, the individualizing power, influence, or constitution which they represented, began to force itself upon speculative minds, and so dawned the metaphysical era of mineralogical science which, in conjunction with the growing popularity of alchemy, retained the science in a quasi-groteseque phase of poetical and chimerical invention.

The ripening spirit of scientific investigation received a fresh impulse from the enthusiasm and learning of George Agricola in the sixteenth century. He was a man of marvelous acquisitions. All the knowledge of his time, all the inherited wisdom of previous ages, with their speculations and vagaries of thought, were known to him. He was finally a critical mind. He weighed carefully his conclusions, and so became the real pioneer in the creation of a mineralogical science which began to reveal some of the features which characterize it to-day. E. Lehman, his translator, says of him: "He was the first in modern times who reflected upon mineralogical subjects with perseverance, unprejudiced judgment, and fairness, and wrote with Grecian elegance." He discussed the geognostic problem of the earth's surface, the character, nature, and processes of volcanic action, the features of fossils, the circulation of the atmosphere. He studied the movement of water, its geological and chemical activity, its physical properties; he wrote upon air and heat, the currents of the air, their causes, upon earthquakes, their kinds, upon the heat and volcanic fires of the earth, upon the origin of mountains, upon mining and peculiarities and changes in fissures, vein matter, etc., upon mineral earths in their general relations, their origin and character, upon the features of stones, their formation and their physical features. He brought into notice, in this relation, besides the color, taste, odor, luster, hardness and transparency of minerals, their density and gravity, their roughness and smoothness, etc. His treatment of these subjects is somewhat pedantic and scholastic. He introduces a subject, as water, gives some proposed explanation of its occurrence, accompanied by proofs, these in turn he overthrows, then follows a second interpretation of the phenomenon, considered with new arguments for its support, which are, in turn, destroyed; the series of alternating propositions with their appropriate discomfiture being concluded by his own hypothesis, which naturally remains unchanged, *nem. contrad.*

He adopted the division of the four principal elements in minerals as the earthy, saline, ignitable and metalliferous. The term fossil expressed all the mineral contents of the earth's crust, without reference to their organic origin. He separated these mineral sections into groups; as under earthy, the siliceous, argillaceous, barite-bearing, talc-bearing, calcareous; under the saline, cooking salts, sulphur salts, etc.; under the ignitable, coal, graphite, bitumen, etc.; under the metallic, the argentiferous, auriferous, etc. These divisions were again broken up into subordinate generic (specific) heads; as under the siliceous he placed quartz, flint, which again received a varietal analysis, as under quartz he placed rock crystal, prase, chalcedony, amethyst, while again, according to their quality (Sippschaft), these varieties are still further dissected, as in amethyst, the common and dense.

Here was classification enough to satisfy the systematist. Already the chemical initiative, introduced through alchemy, had revealed the chemical character of many compounds; mineral species had increased, and we begin to recognize in the pages of Agricola the growing complexity and expansion of the science and its widening nomenclature.

Agricola had noticed the varying crystalline forms of minerals, how many possessed angles, some had triangular faces, others were cubic, as pyrite, while the modifying secondary planes about the terminal pyramids of quartz excited his wonder. He averred that minerals, especially crystals, had been formed from a pure liquid solution.

Hieronymus Cardanus in 1663 wrote upon the nature and forms of minerals, especially of gems. It was gems whose conspicuous beauty, distinctions in color, and crystalline individuality from the first attracted attention and afforded grounds for speculation. Cardanus wondered over the six-sided form of quartz (crystallus). He suggested that it might have arisen, as did the hexagonal form of the bee's cell, from the surrounding and reciprocal pressure of spheres, but abandoned this physical explanation and assumed an implanted force which expressed itself in length and breadth and depth in such a way as to give six sides to quartz, and related hexagonal minerals as beryl, a view which was ridiculed by his opponent Scaliger. Christopher Eucelius continued the publication of observations upon the mineral contents of the earth which he had seen, and, as with Agricola, made most of his notes upon the minerals of mining regions. It was the industry of mining which in the rise of German mineralogy played an important part in eliciting the attention of students of nature for the inorganic products of the recesses of the earth. Eucelius noticed the regularity and persistency of crystals, and expressed his admiration of the activity of nature in the depths of the earth (*Adeo non ociosa est natura, ipsis in terrae visceribus, ipsis in tenebris*) where "she displayed her geometrical power" in these crystallized masses, and where too, as he says, he had seen the impressions of little fishes, and the "traces of lions and wolves."

Crystallography in its adaptation to the study of natural forms received an important impulse from Wentzel Jamitzer, who prepared 140 models of geometrical forms, in which the simple forms were abundantly modified and were grouped in composite multiples, so as to suggest twinning and trilling. Caesalpinus, Gesner, Kentman, living at the end of the sixteenth and beginning of the seventeenth centuries, attempted to reveal the secret of crystallization. The first artificially prepared alum, saltpeter and sugar crystals, and said of quartz, which from its universality and perfect crystallization challenged attention, that it had been formed from the purest substance, and so in its six-sided form more nearly approached the circle, which might be regarded as the perfection of form and most expressive of the purest liquids. He imagined the terminal pyramid of quartz was produced by deficiency of material for the continuation of the prismatic faces, and that it was more clear and less contaminated than the rest of the crystal, in which, as it were, the dregs of the solution settled. Gesner pointed out irregularities in the angles and faces of quartz, and Kentman observed and described natural crystals.

Peter von Aries imparted some of the mediæval romanticism to his conceptions when he assumed, at the beginning of the seventeenth century, a correspondence between the seven metals, the seven precious stones and the seven planets. The moon symbolized silver and quartz. Of the form of quartz, he speculated as follows: "When the earthy and supernatural matter separates itself from water, it (the matter) struggles in every part to consolidate itself, and lines (radii), as if drawn from some central point, appear to shoot outward toward the circumference. But, as they (the lines) meet opposing lines, they cannot complete a circle, but only (through peripheral impact) form a six-sided figure." (*Sympathia septem metallorum ac septem selectorum lapidum ad planetas.*)

The distinguished Anselmus Boetius de Boot wrote in his "History of Gems and Stones" that the formative principle in minerals was a lapidifying power. Matter separated from solution through withdrawal of heat was drawn into angular shapes, and stones which increase through growth, as crystals, possess a force not dissimilar to that of plants, whereby they are formed. The six-sided form of quartz he believed inexplicable or to be referred to such causes as give peculiar shaped leaves and flowers to plants. Paracelsus preceded Peter von Arles in the vagaries of imagination which connected the metals and minerals with the seven planets and neighboring stars. These metals and minerals ejected from these distant orbs had fallen on the earth, but the quartzes, beryls and citrine had been "coagulated" in the "snow stars." These oddities and mystifying fancies were reflected in the writings of Baptista van Helmont, which involved fabulous and metaphysical explanations, the crude substitute for more radical knowledge which was then unattainable. He, however, contested Paracelsus' assertion, the time-honored fancy of the Greeks, that quartz was an obdurate, irreducible ice, saying it was opposed to the essence of life that one thing should pass into another by an exterior influence, viz., that snow by cold should become crystal. Since he further avers everything has its seed, beginning (Archeus), from which it ever new arises and by which it receives its form, that, on account of special seed or germs (*propter specialia semina*), stones received their configuration, not less constantly and regularly than the breeds of animals.

Crystallography received a veritable contribution in the mathematical dissertations of Johannes Kepler, who took five geometrical solids and evolved from them a series of forms, related and interdependent, of which many are exactly reproduced in nature. The Jesuit philosopher, Athanasius Kircher, attacked anew the ever-present problem of crystalline forms, and, like so many of his predecessors, fixed his eyes on the enigmatical six-sided, pyramid-terminated quartz. He asserted that it derived its form from the peculiar endowments of the salt composing it, that in all salts a force moved their particles outward from a center along four, five, or more lines, and so four, five, or six sided figures were created, the interlinear spaces being filled up by inrushing particles brought thither by a certain magnetic impulse.

Erasmus Bartholin, a distinguished mathematician, encountered the then newly discovered transparent (1670) Iceland spar. He measured its angles, found out their permanency, even in the smallest cleavage fragments, dissolved it in acids, examined its colors, and with astonishment recorded its power of producing duplicate images (double refraction). Huygens examined with the greatest care this phenomenon of double refraction, and so exhaustively followed up its laws as to leave little for subsequent investigation. He also detected double refraction in quartz. He anticipated some modern molecular theories, in his suggestion that calc-spar (calcite) was made up of ultimate ellipsoids, heaped up in such a way as to form rhombohedral pyramids, and that the points of their consecutive contact along certain planes, parallel to the rhombohedral faces, formed surfaces of easy cleavage.

The microscope, which had been invented by Zacharias Jansens about 1590, had been improved, and began to play an important role in the advances made by natural science in every direction. Leeuwenhoek adapted it in an original way to mineralogical research, and revealed the minute crystallization of minerals, and turned his attention to the forms of alum, carbonate of soda, saltpeter, sulphate of copper, Glauber's salt, and sal ammoniac. Isaac Newton calculated the thickness of the thinnest plates of mica and gypsum, the cleavage of which latter had awakened in Leeuwenhoek the liveliest admiration. It was indeed from his experiments upon the double refraction of light in calc-spar that led Newton to advance his theory of the four-sided nature of light and to oppose the theory of wave motion. Physics were making strides in the domain of mineralogy, dawning conceptions of crystalline regularity were making a way for the generalizations of Steno Romé de Lisle and Häuy, philosophical theories were realizing more fully the molecular forces playing in the substance of inorganic compounds; but chemistry had yet done little toward determining their constitution, and systematic mineralogy made unimportant progress, nor was to until the elements of chemical analysis, per-

fected a century later, were elaborated. Robert Boyle concludes this period of mineralogical development, following the division arranged by Dr. C. M. Marx in his work on the "History of Crystallography," which we have here in some parts almost literally presented ("Geschichte der Crystallkunde," von Dr. C. M. Marx, Carlsruhe und Baden, 1825).

Robert Boyle observed the geometric outlines of minerals, and made some observations upon the cavities in stones, lined with minute crystals formed, as he remarks, by a lapidifying juice (*succus lapidescens*) of great purity. He also called attention to the lamellar texture of many minerals and made a long, patient series of notes and descriptions upon crystalline forms. The next stage of growth was now about to usher upon the science as known to men the profound and varied facts which built up crystallography, and laid in chemical composition the foundation of a rational system.

INTERESTING DISCOVERIES OF EGYPTIAN RELICS.

THE discoveries made by the French Director of Excavations in Egypt, M. De Morgan, near one of two ancient brick pyramids not far from Cairo, are exciting the deepest interest in London and Paris, as well as among the tourists and European residents on the Nile. Brief allusions were made early in the month in the current news of the fine arts, but these finds are so important that further notice is necessary.

The tombs and presumably the brick pyramid (since bricks found in the subterranean tombs are like those of that monument itself) belong to kings and princesses of the twelfth dynasty.

Egyptologists have divided the dynasties of the Pharaohs into thirty and group the thirty into dynasties, 1 to 11, 12 to 19, and 20 to 30. This is merely for convenience, and was unknown to Herodotus, Manetho, Josephus and others who have written about the early kings. Nor did the Egyptians themselves have any such system. From the first group (1 to 11) we have only the slenderest details and no jewelry or gold ornaments. Indeed, it is not till we reach the eighteenth that we get in our museums and that of Egypt certain objects that belong to the minor arts of personal decoration and so forth. The excitement that M. De Morgan's find has aroused is therefore natural; for here are art works of very great beauty from the tombs of at least three Pharaohs—Usertsen II. and III. and Amen-em-hat III., whose reigns are placed by Mariette between 2366 and 2300 B. C., or about 4,000 years ago.

Concerning Usertsen II. we know that a Semitic tribe called the Aamu came from a country named Absha with tribute. Concerning Usertsen III. we are told by the inscriptions that he made a great campaign up the Nile against the black Nubians and built a temple at Elephantine. As to Amen-em-hat III., he is of even greater note, since it was he who built in the Fayum the great artificial reservoir for his people, which was called Lake Moeris, the site of which is still debated. He also built the labyrinth, said to have had 1,500 rooms above ground and 1,500 below. Lake Moeris stored up the water of the Nile during the season of floods, and was tapped in the dry season as required.

Herodotus has a quaint story picked up in Egypt about 450 B. C., which may relate to one of the brick pyramids at Dashur, concerning a king of the unrecognizable name Asychis. He wrote on a piece of stone the following apology: "Do not disparage my worth by comparing me to those pyramids composed of stone. I am as much superior to them as Jove is superior to the rest of the deities. For, thrusting poles down into the lake, and collecting the mud deposited on the poles, bricks were fashioned, and in this manner was I made." The meaning of which may possibly be that, in the opinion of the king, or of the Egyptian who told Herodotus this particular yarn, it was more honorable to a pyramid to be built of the fertile mud of the Nile than the dead stone of the desert.

Humility like this seems to have failed to put the grave robber off the scent for funereal treasures, since the brick pyramid in question has been ruined in every direction, and is now only ninety feet high, a long mound of disintegrated, sun-dried brick, with its top a mere crater. Even the tombs at some distance were rifled long before Herodotus, yet the robbers either missed some of the spoil, or themselves proceeded to bury some with the intention of returning at a better moment. Some side chapels, or niches, were found still walled up, but the richest treasures were discovered several feet under the floor of a gallery strewn with skulls, broken or empty boxes, and fragments of sarcophagi.

M. De Morgan must be credited with a good deal of sagacity in this discovery. He is the third important director of excavations in Egypt since Napoleon III. lent Mariette to the Egyptians. After Mariette came Maspero; after Maspero came Grebault; now it is his turn to uphold the honor of France in a field opened by Napoleon the Great a century ago. His excavations in the Caucasus for the French government some years ago prepared him for this work. Having selected the brick pyramid as a good site for very early tombs, he drove a shaft directly through its center to the bed rock without positive results. Then he moved to some distance and began sinking shafts, well knowing the efforts made by these kings to conceal their tombs. Finally, on Feb. 28, he struck an unimportant tomb. But the bricks were like those of the pyramid. He had found the radius. On March 2, his foreman reported a door of cut stone; breaking through that a low tortuous gallery was found heading toward the pyramid and ending in a tomb, with the remains of a sarcophagus and a statue carved in diorite, which robbers had broken up, perhaps thinking that they contained treasures concealed in the stone.

From the tomb Morgan worked into a long gallery running east and west, having on the north four doors of white limestone from Massarah, on the other, or east side of the Nile. These led into chambers cut in the bedrock and lined with Massarah cut stone. One has an elliptical vaulted ceiling formed of great blocks hollowed out. Here were broken sarcophagi of a king and queen, skulls, lamps, and broken tiling stones. Some granite boxes containing lamps had been left intact. Others were empty. By this time the air had become so foul that the lights began to dim; having found a walled place across the gallery, M. De Morgan withdrew, plotted out on the surface of the ground the place of that wall and set his men to dig.

Two days later the old shaft was struck which gave the needed ventilation. Below the grand east and west gallery he found a row of chambers, with eight sarcophagi and various empty granite coffers. He has made out the tombs of thirteen princes and princesses. On March 6, he found below the floor of a gallery the first treasure, with its box mouldered away and the jewelry mixed in earth and sand. On the 7th he found a second cache. How much more will be discovered no one can tell, but what we have is indeed a valuable addition to our knowledge of the artistic powers of the Egyptians long before the earliest date assigned by scholars to the Trojan war.

Among the gold finds are a crouching lion, cypresses of gold, a necklace of lion heads, bivalve shells of gold. A breast ornament bearing the cartouche of Amen-em-hat III. shows that king raising his battle ax to smite an Asiatic enemy, while he tramples a negro under foot. There are bronze and silver mirrors, heightened with gold, jewelry with amethysts, carnelians, lapis lazuli and Egyptian emeralds, vases of carnelian, obsidian and alabaster. The carving of some of these jewels, especially in the rings, is said to be marvelous. Examined with a glass, the human figures are seen to have every muscle correctly modeled. Necklaces, bracelets, chased and set with hard stones and pearls, are said to be marvels of beauty, surpassing all the work of later reigns, which are mere debased copies of these ancient ornaments. In texts the find is not rich; but few pyramids have yielded much in that line. In fine, M. De Morgan has signalized his advent to the responsible position he holds by a feat which is likely to remain one of the most brilliant in the history of Egyptology.

A PHENOMENAL JUMPER.

AMONG the many unique features at Barnum & Bailey's show, which is now exhibiting at the Madison Square Garden, in this city, the jumping of Joseph Parker stands out as a conspicuous attraction. With half a dozen chairs, as many nine inch bricks, a pair of nine pound dumb bells, and a healthy-sized horse, Parker gives a series of exhibitions which rarely fail to command attention and applause.

The agile Englishman was born in Dudley, Worcestershire, thirty-two years ago, but subsequently moved to Tipton, which has been his headquarters for the past twenty years. In his street attire he looks too heavy for an athlete, and the modesty of his bearing adds to the deception. When stripped, however, a glance serves to convince the most casual observer that Parker's development is just what is needed for the branch of athletics to which he devotes himself. He stands 5 feet 6 inches tall. His legs are slightly bowed, owing to the abnormal development of the upper leg. He measures 26 inches around the thigh and 18 inches around the calf. He weighs in condition 174 pounds, but little of this is to be found around his waist, which is only 28 inches.

Parker measures 42 inches around the chest. His reach of arm is so phenomenal that when standing to attention the finger tips reach below the knee joint. He attributes most of his success to his expanse of chest and reach, as he can carry bells with impunity the weight of which would anchor a less robust jumper, while the extra leverage afforded by his length of arm heightens the effect of his efforts. He usually carries nine pound bells in his tricks, but when jumping for distance on special occasions, he uses much heavier weights.

Parker has been before the public for about four years, but only recently came to this country to fill the season's engagement with Barnum & Bailey. The limited time allowed for his act and the rival attractions being presented at the same time all over the arena have so far prevented many patrons of the great show from forming a thorough estimate of the Englishman's ability, but the aspiring young athletes fully appreciate his performance, and their favorite vantage point is on the Twenty-sixth street side of the garden, where they wait patiently for "Circus display No. 10." When this is ushered in a boarding is stretched on the floor between rings one and two, and Parker appears clad in skin-fitting gymnastic costume and heavy jumping pumps. A few of his many astonishing feats are as follows:

Jumping from the end of a brick over a chair on to another brick, thence over another chair to the third brick, and, finally, over a chair twelve feet away, without pausing between jumps or disturbing either chairs or bricks.

Jumping lengthwise over six chairs placed in line, without any impetus beyond two preliminary springs.

With ankles bound together, jumping over a cross bar 5 feet 6 inches from the ground.

The interest becomes absorbing when Parker changes his shoes for heelless slippers and steps on a brick to clear a horse at one bound. His ankles are then tied, but he leaps over a 15 hand horse without ruffling a hair on the neatly groomed equine. After his ankles are released another horse of greater height and girth is brought out. T e jumper poises himself carefully on the precarious footing afforded by the brick and clears the live obstacle in magnificent style, dropping the bells on the take-off side when he has projected himself to the necessary height. An attendant is then poised across the backs of two chairs. Parker braces himself for a crowning effort, bounds on to the man's face and off again with such celerity and lightness that those not near enough to see the smudge left by the slipper generally miss the point of the trick.

Parker's admirers claim that he is without a peer at standing forward, standing backward, and standing high jumping.

Parker is a married man and the proud parent of a twelve year old daughter who has no equal at her age in her father's department of athletics. The Englishman never trains, in the old-fashioned sense of the word. He nourishes himself solidly and liberally, and his continuous engagements serve to keep him in condition. Like most Englishmen, he believes implicitly in good "grooming," and submits himself to a thorough rubbing every time he strips. His muscles are finely developed, and he has all the appearance of a man who has healthy propensities and lives up to his theories. He has a pronounced taste for running, but he does not over-indulge in the sport, for fear his jumping muscles might lose their flexibility. After his set at the Garden, however, he generally lets himself out a bit and sprints across the arena with the gait of a man who has learned to "hop the twig" at Sheffield.—*N. Y. Sun.*

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